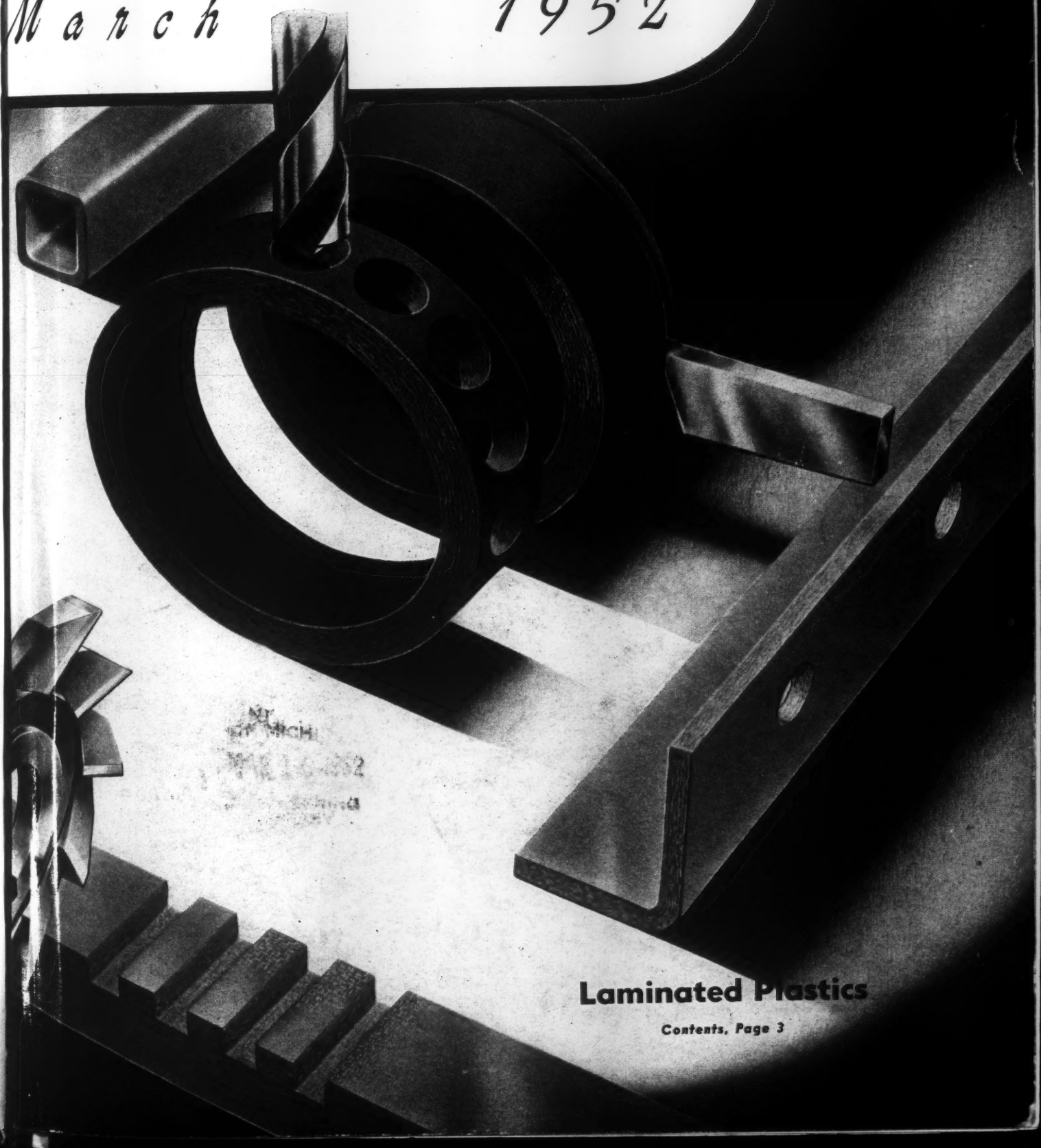
# MACHINE DESIGN

March 1952



**Laminated Plastics**

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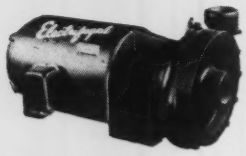

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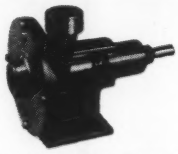

**PEDESTAL MOUNTED PUMP**—For use where flexible coupling or V-belt drive is desired. Essentially the same pump as package pump at left, except that bearing bracket is substituted for motor. A-C also furnishes motor, drive, control. See ratings at left.

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# MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

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# Over the Board

### CHBS

Most people love to give someone else an opinion. So the Department of Commerce, in full official recognition of that fact, has come up with a brand new agency, the "Clearing House for Beneficial Suggestions," for just that purpose. Although most people in industry today would probably leap at the chance to give government a "beneficial suggestion" or two, actually the agency will be a kind of king-sized suggestion box for ideas to improve efficiency—in industry, of course. It is expected that suggestions will be condensed into a newsletter, and then be distributed to help expedite defense production. Reminds us of the Navy's *Beneficial Suggestions Digest*, whose most recent issue contains an excellent item to the effect that a ball-point pen is better than a stylus for lettering mimeograph stencils.

### This Month's Cover

To depict the theme of associate editor Ben Hummel's article which begins on Page 112, our artist has executed a pleasing composition of variously shaped laminated plastic parts. Both postforming and machining are represented in the shapes illustrated. Like most of our other cover designs by George Farnsworth (January was an exception) this one has been executed by the airbrush technique which combines clarity and realism comparable to photography with latitude for the free exercise of imagination.

### FBI

The other day a fat volume entitled *FBI Register* 1950-51 came to our office for review. Wondering whether this might be a list of Communists and other suspected criminals we turned the pages with considerable curiosity. No, the book had nothing to do with J. Edgar Hoover's excellent organization. Actually it is a publication of the Federation of British Industries, an association of over 6000 manufacturers and 280 trade associations in the British Isles. Alphabetical lists include company names, products and services, and tradenames.

### Operations Research

A new approach to the solution of overall industrial problems is one of the happier outcomes of World War II. Techniques which were successfully applied in large-scale military operations have been boiled down into a science which is becoming known as Operations Research or OR. Earl Lamm tells about it in this issue, beginning on Page 102. But don't expect to become an operations researcher in one easy lesson. The methods and the mathematics will seem new and strange to the average engineer.

Another relatively new branch of science as related to human enterprise came to our attention recently — Techno-Economics — which is said to bring together the economist, the marketing specialist, the transportation expert, the industrial engineer, and scientists to solve research problems on a broad front. Although the name sounds suspiciously like Technocracy, we are assured that Techno-Economics is strictly "brass tacks" stuff which has already proved its worth. In fact, it might be regarded as a first cousin of Operations Research.

### Coming Next Month

The usual harbingers of spring are now accustomed to moving over for MACHINE DESIGN's annual Drives and Controls issue. This year's edition, it can now be revealed, will be something special as it will include a 64-page photo-offset section on the selection and application of electric motors. Written by associate editor Jack Greve, this work is a comprehensive manual which no design engineer can afford to be without. Other features of the issue will include contributed articles on various aspects of electrical, hydraulic, pneumatic and mechanical drive and control problems.

# FREE Cylinder Catalog and Templates offered by Ortman-Miller Co.

***Book outlines several special features of O-M cylinders.***

## FREE

A new, 28 page catalog has just been released by the Ortman-Miller Machine Co. which gives complete engineering specifications, data on O-M's special internal locking system and special full listing of O-M parts. Prepared for designers and users of cylinders for any application, it covers standard, oversize and 2-1 piston rods, giving full information on all sizes from 1½" to 8" bores.

## SPECIAL FEATURES

Included are detailed explanations of the many features which have made ORTMAN-MILLER cylinders standard in thousands of plants throughout the country. Detailed drawings and copy explain the special shear bar assembly which completely eliminates bulky end caps and tie rods, thus saving up to ⅓ in space. In addition, it shows the vast number of interchangeable mountings and applications which almost always eliminate the need for special castings or patterns. This feature alone not only saves initial costs, but cuts down on inventory and greatly speeds up delivery on every order.

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For your FREE Catalog or templates, use the coupon in the ad at the right. Or write to ORTMAN-MILLER Machine Co., 1210 150th St., Hammond, Indiana.

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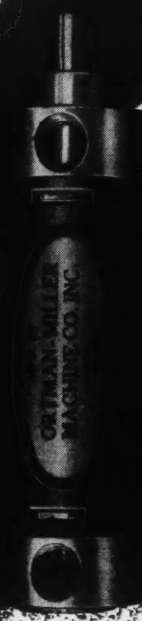

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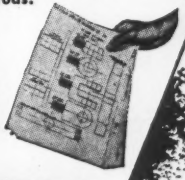

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# TOPICS

## . . . IN ENGINEERING AND RESEARCH

### Soldering Carbon to Metal

Carbon, which resists "wetting" in usual brazing methods, can now be silver-soldered or copper-brazed to metal. The process, originated by Stackpole Carbon Co., was developed to solder carbon electric contacts or brushes directly to metal arms or leaf springs. Maximum dimensions are limited to ⅜-inch, although soldering can be performed over greater lengths if the metal has the same coefficient of expansion as the carbon.

### Erosion Resistance Improved by Nickel Plating

Protection of aluminum from flying grit and sand, particularly important for exposed aircraft parts, can be effected by a nickel-plastic surface coating recently developed. A synthetic base is first sprayed on the aluminum, the piece is then dried, and nickel is electrodeposited to the desired thickness. According to Bart Laboratories Corp., developers of the method, intricate shapes can be coated, and the coating is highly resistant to corrosion—as well as to erosion.

### Vacuum Impregnation Seals Castings

"Leakers" or "weepers"—castings with small capillary defects—can be vacuum impregnated to make them pressure proof, according to F. J. Stokes Machine Co. The castings to be impregnated are placed in a vacuum chamber, and air is removed. When sodium silicate or other heat-resistant materials are introduced, they fill all capillary voids in the castings. Visible porosities which permit spurting under hydraulic pressure cannot be so treated.

### New Value for Absolute Viscosity of Water

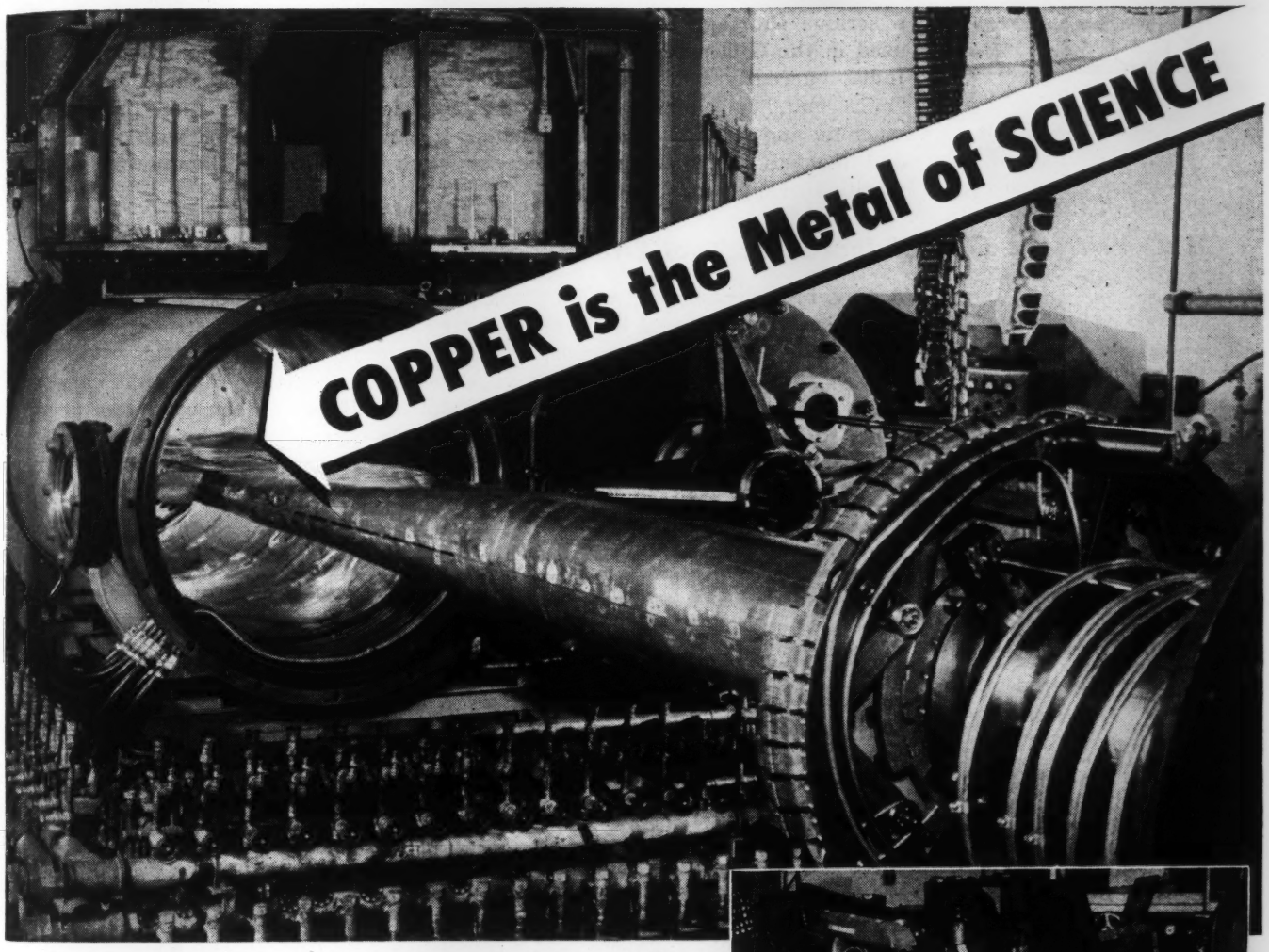
Serving almost universally as a reference standard of viscosity, water will soon be assigned a new absolute viscosity value. The new value is 0.01002-poise (dyne-sec per sq cm) at 20 C, as compared with 0.01005-poise formerly accepted. Determined by a highly accurate capillary-flow method, the revised figure will be used after July 1 by the National Bureau of Standards as the primary standard for calibrating viscometers and for evaluating secondary standards issued as viscometer calibrating liquids.

### Reports Condensed on Cards

Sixty letter-size pages can be reproduced on one 3 by 5-inch opaque file card, which has many of the virtues of microfilm, plus ease of filing. By reducing each page to half postage-stamp size, 6000 pages can be condensed into one inch of file space, along with indexing information. The cards, developed by Technical Microcard Publishing Corp., are enlarged to their original size by a portable projector.

### Flexible Mica Sheet Has High Dielectric Strength

A new process by which minute flakes of mica are formed into a continuous flexible mica sheet from 0.002 to 0.006-inch thick may alleviate




*D and D Stem being inserted in Cyclotron; made of Revere Electrolytic high-conductivity copper, hot rolled and annealed, 1/8" thick. Note also large number of bronze valves to control flow of cooling water through brass pipe.*

● For many years Revere has been saying that "Copper is the metal of invention." It has high electrical and heat conductivity, excellent resistance to corrosion, is easily fabricated and formed, so that it is attractive to designers and inventors, as well as to manufacturers. Now we say it is also "The metal of science," because it is so essential to the operation of most scientific devices.

The pictures on this page illustrate some of its uses in a cyclotron, built by and for the Nuclear Physics Laboratory of the University of Washington in Seattle. The instrument was designed and constructed so far as possible by University personnel, who were completely successful in working copper into the most complicated shapes.

Revere collaborated on the project in various ways, and furnished copper bar, sheet, rod and tube to the University's high specifications. Remember that Revere will be glad to consult with you on your problems concerning copper and copper alloys, and aluminum alloys.

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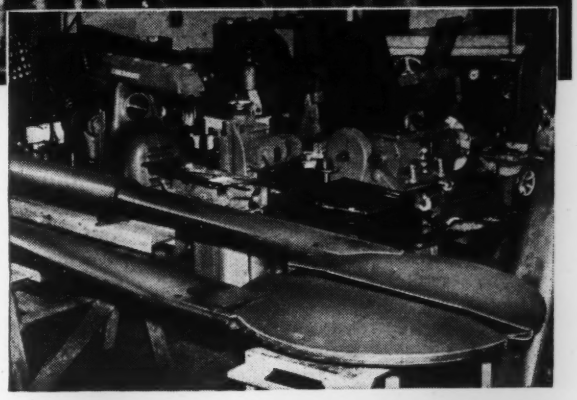
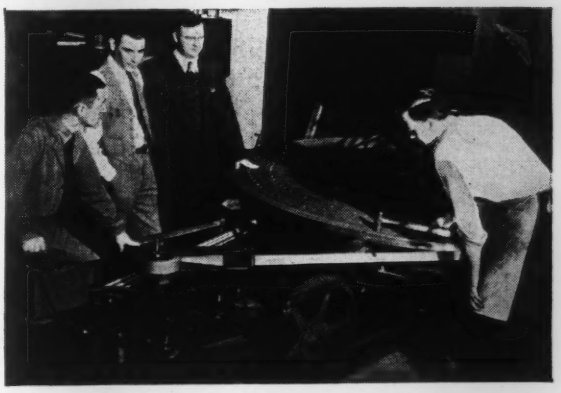


*Photo taken in the University of Washington shop during fabrication of the two Ds and D Stems.*



*Seven miles of Revere copper bus bar were wound into great coils for the cyclotron electromagnet. The University built the winding machine itself, and wound the coils in its own shop. The special Revere bar is soft temper, free from scale, with rounded edges.*

**TOPICS**

a serious shortage in this material. Low-quality American mica can be used in the G-E process instead of the high-grade product imported from India, currently listed as a strategic material. This mica sheet, called "mica mat," is claimed to have better dielectric strength than present machine and hand-laid mica products. It can be impregnated with resins and bonded to paper, glass fiber or cloth for forming, laminating or machine-wrapping.

### *High-Pressure Oil Jet Increases Tool Life*

A tiny, high-pressure jet of oil aimed at the cutting-tool edge from underneath can increase tool life from 300 to 1200 per cent. The stream of oil in the new Gulf Research Corp. system, passing between the side relief face of the tool and the work, is vaporized at the cutting edge, thus carrying away heat. Vaporized and excess oil condenses on the chip, tool or work to help in lubrication and cooling, or is carried away by a protecting "shower curtain" of oil. Reduction in surface roughness from 200 to 60 microinches rms is also claimed.

## . . . IN GOVERNMENT AND INDUSTRY

### *Why Engineers Are Needed*

One reason for the large demand for engineers in defense production is the complexity of modern military equipment. Consider these rather startling facts. The F-86D Sabre jet plane required 1,131,992 man-hours for engineering. Its World War II counterpart, the P-51 Mustang needed only 41,880 man-hours. Over 6570 drawings were involved for the F-86D, against 1100 for the Mustang.

### *Small Business—Feast or Famine?*

Almost every major government agency has now reported on small business' share of the defense kitty. Latest is the tabulation on the Department of the Army's scorecard which shows that 75.8 per cent of all contracts awarded during 1951, equal to 29.8 per cent in dollar volume, went to small business. The Army Audit Agency, which studied 13 major defense contracts, reports that 42 per cent of the money found its way into the hands of small business through subcontracting. Information from 46 executive agencies compiled by the General Service Administration shows that small business supplies about one-third of all Federal civilian procurement.

### *Breakdown in Rail Transportation Forecast*

By mid-1952 a serious bottleneck in the nation's rail transportation services will occur, according to Frank G. Moore of the National Industrial Traffic League, due to a crippling shortage of freight cars. The railroads now have fewer cars to ship defense materials than at the peak of World War II. The League, in requesting a "continuous and uniform" allocation of steel, points out that car production will have to be stepped up to provide for the "full-speed-ahead" agricultural and defense production slated for mid-year.

### *Heavy Press Program Pans Out for Air Force*

The Air Force's program of developing extra-large die-forging and extrusion presses is "definitely on the right track," according to Roswell L. Gilpatric, under secretary of the Air Force. A recent survey of air craft manufacturers showed that forging presses up to 50,000 tons capacity —and possibly up to 75,000 tons—could be used, as well as extrusion presses of over 8000 tons capacity. Four presses are under contract for construction, with 14 more still on the drawing boards.

# Specialization or Versatility?

WHEN, on this page last month, we commented on the decline of skills among machinery users we were unprepared for the additional slant which came to our notice a few days later. The operator who manipulates the controls of a production machine may be thought of as the user for whom the designer engineers these controls. But in the larger sense it is for the tool engineers and design engineers in whose plant the equipment operates that the machine as a whole is designed.

These engineers, in their role as machine users, recently answered the American Society of Tool Engineers in various ways when invited to tell what they wanted in future metal-forming equipment. Significantly, only three per cent of the total companies reporting indicated that conventional equipment of a relatively standardized nature was satisfactory to meet present and future needs. Thirty-four per cent wanted new *special equipment* including bigger presses and improved designs.

This means that eleven times as many people wanted *special* equipment as would be satisfied with *standard* equipment. It would almost seem as if many engineers—as machinery users—are content to relinquish some of their skills in designing for production or in devising ingenious tooling. In effect they are passing the buck to the equipment designers.

Before going overboard in their demands for special equipment, the designers of parts to be made on these machines, and their tool-engineering colleagues, should give careful thought to the practical and economic advantages of using standard equipment, adapting their designs and their tooling to what is at hand or readily available.

These engineers, by their demands, play a major part in dictating production equipment design. In the huge area of manufacturing where relatively limited production runs of a single part are customary, and in much of today's so-called defense work, the real secret of production economy and speed lies in versatility—in equipment, in tooling and in engineering.

Colin Carmichael

EDITOR

# OPERATIONS RESEARCH

DURING the last war the techniques of scientific research were applied to a variety of problems which had never before been approached in this manner. British scientists were asked to investigate the problem of how best to use the inadequate amount of available radar equipment to ward off the enemy's air raids; bomber and fighter plane tactics were analyzed mathematically and optimum dispersal patterns for ships in convoy were determined from mathematical and probability equations. In many cases the problems which were assigned to scientists for investigation had been widely held to be unsusceptible to scientific methods of attack. Nevertheless, each problem was analyzed in the best scientific tradition, as though it were a problem in physics or mechanical engineering. The variables involved were measured, and experiments were carried out where necessary to determine the causal relationships and to verify the results.

Most of these problems did not lie in any well-defined field of science and were new to the scientists working on them. A new term, therefore, seemed necessary. The term *Operations Research* was chosen to designate the adoption of scientific methods for investigating problems outside conventional fields of science. At first these problems were mainly in the field of military tactics, but later business and industrial problems were investigated. The war years demonstrated clearly that problems outside conventional fields of science and engineering offered even greater opportunities for progress and improvement, when scientific methods of analysis were utilized, than problems in conventional scientific fields. The future of Operations Research in business and industry is predicted to be even greater than its past successes in the military field.

The techniques of Operations Research are not new —only their wider application. Their importance stems from the fact that the scientific method of analysis is basically an unbiased, systematic method of approach. Psychological studies indicate that physical scientists tend to think in terms of visual images, whereas most military and business men think in terms of verbal images. Thus, scientists who are called upon to study military or industrial problems see them in terms quite different from the traditional point of view.

Sometimes the fact that the Operations Researchers may be unfamilar with the previous practice in the field being studied is an advantage which leads to novel solutions which might never have occurred to anyone brought up in the traditional approaches to the problem. There are "experts" in many fields who are laymen as far as the knowledge and use of scientific methods are concerned.

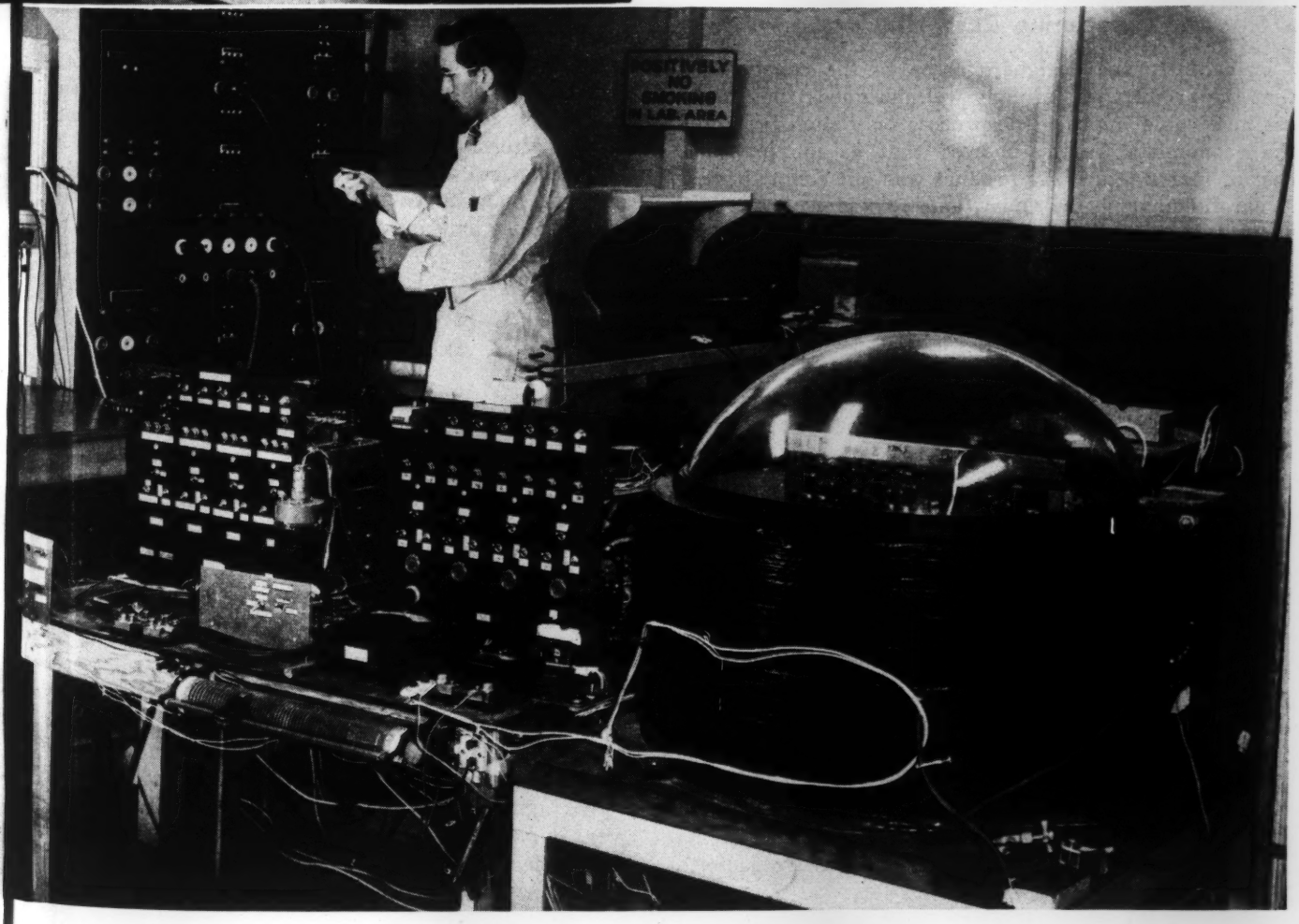
Does this mean that the scientist knows more about war than the militarist? Does he know more about business than the businessman? Definitely not. But he brings to their problems a new twist; he formulates their problems in a new language. And when he does come up with a new solution it is only because the military man and the businessman just never look at the problem in the way that the scientist looks at it.

**Program of Operations Research:** In general, the most effective method of attack is through the co-operative effort of persons experienced in the field of application and scientists skilled in the techniques of Operations Research. The following procedure for carrying out an Operations Research is suggested. It follows closely the established pattern for conducting any industrial and scientific research program:

1. The problem is defined as clearly as possible

2. The problem is considered from an operational point of view, i.e., a result, and the activities which appear to bring about that result are identified as an operation
3. Relation of the operation to be studied to other operations connected with the problem is investigated, to make certain that the operation to be analyzed plays a critical part in the problem
4. An examination is made to determine what data will be required to identify the activities (causal factors) which actually bring about the result

*Photos, courtesy Boeing Airplane Co.*



and to yield the functional relationships between these causal factors, and the result

5. Records are studied, surveys made, and experiments carried out, as necessary, to obtain these data
6. Data are analyzed by statistical methods to determine the functional relationships between the causal factors and the result
7. Result is expressed in the form of an equation, or series of equations, which shows the contribution of the causal factors
8. Results are predicted if the magnitudes of the causal factors are known; or the equations are solved for optimum magnitudes of the causal factors to provide a desired result
9. On the basis of information obtained in the previous step, specific conclusions are drawn and recommendations made concerning the problem.

A typical example will illustrate the method as applied to an engineering problem. Recently the management of a manufacturing company proposed a research program to find out what could be done about one of their products on which they were losing money. Research engineers and designers went to work on the possibilities of redesigning the product; chemists, physicists, and process engineers were assigned to work on improving the steps in its manufacturing process; economists and sales engineers studied the possibilities of increasing sales by finding new markets. Operations Research was assigned to investigate the general overall aspects of the manufacturing procedure.

## Manufacturing Costs—The Key

Reluctantly the designers came to the conclusion that the product was already well-designed; the process men could improve the process only slightly; and the economists' survey showed that at the present cost of manufacture the product was not competitive. A careful analysis by Operations Research, however, showed that almost one-fourth the entire manufacturing cost was incurred because of a detailed final inspection to which each piece was subjected. Therefore, the inspection procedure for this product was chosen as the problem for study in this particular program.

*Definition of Problem:* Could the inspection procedure be changed so that the quality of the product sent to the purchasers would still be sufficiently good for their purposes, with a saving in inspection expense sufficient to put the product on a profitable basis?

*Problem from an Operational Point of View:* The inspection procedure should be looked at as an operation consisting of causative factors and a result. The result is twofold: (1) The quality of the product shipped to customers, and (2) the cost incurred by inspecting. The causative factors consist of (a) the quality of the product before inspection, and (b) the inspection procedure—the lot size, the number of pieces inspected per lot, and the number of defective pieces in the sample considered critical.

*Operation in Relation to Other Operations and in Relation to the Problem:* The first causative factor, the quality of the product before inspection, was directly related to the manufacturing operations which preceded final inspection. Since these operations had already been studied by specialists in manufacturing methods, this causative factor would not be studied further for possible improvement. The other causative factor was concerned exclusively with the operation inspection. As for the relation of inspection to the basic problem of making this product a profitable one, the cost analysis had shown that inspection costs constituted such a large proportion of the total cost of manufacture that a reduction in the cost of inspection would be the most promising solution to the problem.

*Required Data:* The result and the causative factors must be expressible in terms of measurable quantities. The first part of the result, the quality of the product, after inspection, is measurable in terms of the average fraction defective in lots which are shipped after inspection. The second part of the result, cost incurred, is conveniently measured in terms of dollars per inspected lot. In this study it was sufficient to consider only direct labor cost. The first causative factor, the quality of the product before inspection, is measurable in terms of the average fraction defective of lots of finished pieces previous to inspection, and the second causative factor, the inspection procedure, is already expressed in terms of numerical quantities.

*Obtaining the Required Data:* Magnitudes for the two causative factors and the two parts of the result must be obtained for each inspection plan under consideration. For the 100 per cent inspection plan that had been used up to the time of the study, these magnitudes were obtainable from past records. In many applications of Operations Research the required data for the alternative procedures must be obtained by conducting suitable experiments; however, in this case, the magnitudes necessary for comparing alternative inspection plans could be obtained without recourse to experiment by using the principles of statistical sampling theory.

## Savings in Inspection

*Functional Relationship:* These data showed that by tolerating a small percentage of defectives, a considerable savings could be made by changing from a 100 per cent inspection plan to a suitable sampling inspection plan. However, a sampling inspection plan had the disadvantage that complete assurance about the quality of a lot would not be possible, and therefore, an arrangement would have to be worked out with the customers by which they would agree to accept those lots of the product for which the number of defective pieces in a random sample of a given size did not exceed a specified maximum number. By specifying lot and sample sizes, and the maximum number of defective pieces that are tolerated in the sample, the purchaser would be protected to some extent against receiving bad lots of product. However, by making his specifications too rigorous, the purchaser would require the manufacturer to go back

to almost 100 per cent inspection, which would preclude the cost savings intended.

It was clear that functional relationship exists between the magnitudes connected with the inspection procedure (causative factors) and the two parts of the result: (1) Quality of product shipped to customers, and (2) the cost incurred by inspecting. The more pieces inspected, the less the risk of shipping products of unacceptable quality, but the greater the cost. This risk was expressible numerically by applying the laws of probability. A definite risk was then agreed to by the manufacturer and his customers. Generally a customer will accept a small risk of receiving bad lots of product because the resulting reduction in inspection cost is usually reflected in a reduced price.

*Functional Relationships in Terms of Equations:* The functional relationships between the causative factors (the quality of the product before inspection, the lot size, the number of pieces inspected per lot, and the number of defective pieces considered critical) and the two parts of the result (the quality of the inspected product, and the cost incurred in inspecting) were expressible in terms of equations by applying the principles of probability and statistics. A single sampling plan was first considered, and for it the basic relationships appeared as follows:

$$P[A] = \sum_{x=0}^{c} \frac{\binom{NP_t}{x}\binom{N-NP_t}{n-x}}{\binom{N}{n}}$$

and

$$C = \frac{kI}{N}$$

where

$P[A]$ = Probability of accepting the lot (i.e., shipping it to a customer)

$P_t$ = A measure of the quality of product before inspection

$N$ = Lot size

$n$ = Sample size (number of pieces inspected)

$c$ = The number of defective pieces in the sample considered critical (i.e., the lot would not be shipped to customers without further action if the number of defective pieces in the sample was greater than $c$)

$x$ = Number of defective pieces in sample

$C$ = Inspection cost per lot shipped

$k$ = Cost of inspecting one piece

$I$ = Average number of pieces inspected per lot.

Similar relationships could be established for sampling plans other than single sampling, e.g., multiple sampling plans.

*Solving for Optimum Magnitudes:* Although some additional factors had to be considered, such as what is done to a rejected lot, these relationships served as a basis for determining an optimum sampling inspection plan by indicating the number of pieces from each lot which should be inspected, and the maximum number of defective pieces in the sample which would still mean accepting the lot.

*Conclusions and Recommendations:* On the basis of the results obtained in the previous step, and an evaluation of the relative practical advantages and disadvantages of the various types of inspection plans under consideration, a specific inspection plan was recommended. This plan was put into operation, and saved the manufacturer more than enough on inspection costs to make the product a profitable part of the company's line of products.

**Field of Operations:** Although the term Operations Research was originally coined by those working on problems which did not seem to them to belong to any well-defined field of science, on closer examination it is apparent that almost all of these problems

*Photo, courtesy General Electric Co.*

actually could be classified in one or more of such broad fields as Industrial Engineering, Economics, Anthropology, Military Science, etc. It seems advisable, therefore, to de-emphasize the distinction between Operations Research and conventional scientific research, and to consider as simply scientific research in its broadest aspect.

Scientific methods of approach have been so tremendously fruitful in solving problems in the basic sciences and engineering, that their appropriation for service in other fields certainly seems promising. Considerable progress has already been made in this direction: Economics, Psychology, and even Sociology, have partially evolved from their qualitative and descriptive beginnings into experimental, mathematical, quantitative sciences. The field of military science provides an even more forceful example: Under the pressure of two world wars, and the threat of a third, the demand for scientific investigations for the military has increased enormously. Ballistics and weapon design researches are only a small part of the program which now includes studies in "logistics", combat tactics and psychology, and the mathematical evaluation of entire alternative offensive and defensive plans of operation.

**Basis of Method:** A distinctive feature of Operations Research is often said to be its dependence on probability theory and statistics. But in a sense this is only accidental. A good proportion of the problems, on which this method is brought to bear, involves the human element in the form of personal decisions; and since the human element is widely known to lead to uncertainties, this type of problem can be best formulated in terms of probabilities.

## Other Areas of Use

Another fertile field for Operations Research is the study of complicated systems of events, in which the occurrence of one event is conditioned by the preceding occurrence of other events, and where a great many results may occur with different probabilities. Again, in treating such a problem, a statistical approach is usually necessary to even state the problem and set forth the underlying conditions and assumptions.

Those who look for a day when these problems can be stated in terms of mathematical formulas instead of a probability equation are looking in the wrong direction because the statistical methods of Operations Research are proving more general than the "formula" methods of conventional research, and it is becoming apparent that the latter are merely over-simplifications. No formula in the basic sciences

*Photo, courtesy SoundScriber Corp.*

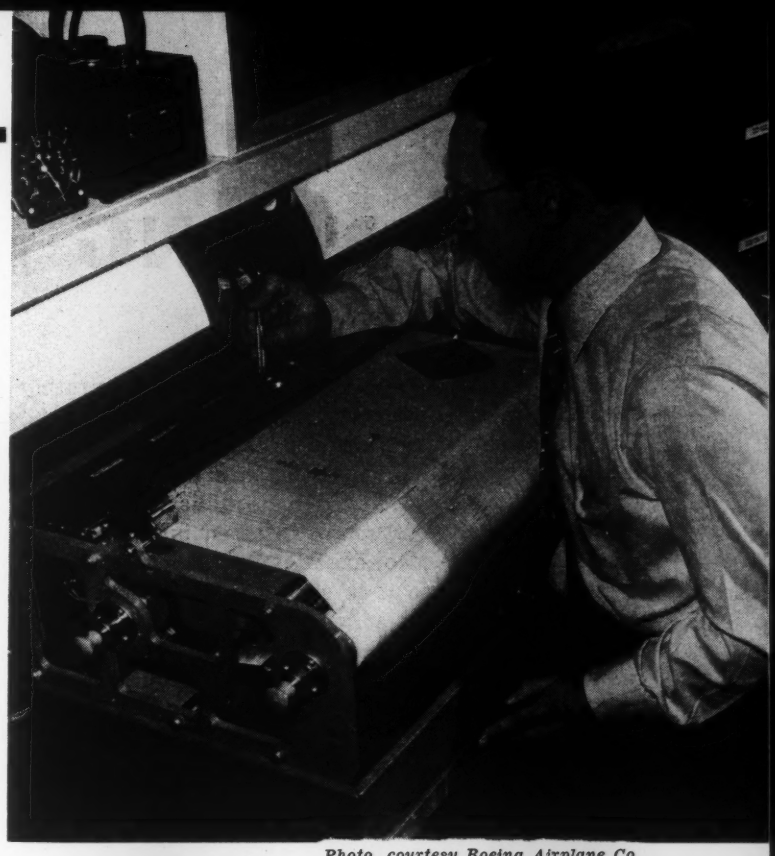
or engineering holds exactly, and this becomes more apparent as more accuracy is required. There is always a certain amount of experimental error. Recognition of this fact is, for example, rapidly changing the engineering concept of "tolerance" of manufactured products from a fixed "yes" or "no" proposition to a statistical frequency distribution. In the sense that statistical techniques are gradually invading conventional research, these methods can be expected to become more like the present Operations Research methods, instead of vice versa.

However, it may be advisable to maintain the traditional difference between conventional research methods and Operations Research until some time when their methods will become less distinguishable. An example may point out the difference which many feel still persists. The history of the typewriter includes a number of investigations which would be classified as conventional types of research, such as chemical studies to improve the hard rubber platen, mechanical studies to improve the lever arrangement of the type bars, machine design studies to improve bearing surfaces, and metallurgical studies to reduce fatigue failures in the stressed parts. However, the arrangement of the keyboard was an Operations Research problem (even though at the time the term was unknown) because its solution necessitated studies outside of the basic scientific and engineering fields: studies on the relative frequency of the use of the various letters in the language, on the time for different types of finger motions, and on the causes of personal rather than mechanical fatigue.

### Early OR Work

Actually the first typewriters were built without the benefit of Operations Research and had alphabetically arranged keyboards, since this seemed most logical to the mechanical inventors. Around 1872 a man, who did not know much about typing but who was familiar with the scientific procedure that had been used to increase the speed of type-setting, suggested a redesigned keyboard following the idea of putting the most frequently used letters in the most accessible places. It has since been estimated that this simple idea increased the amount of typing that can be done, with the same human effort, by an amount equivalent to the combined improvements resulting from all of the chemical, mechanical, and metallurgical improvements that have been developed since.

This was Operations Research in its crudest form. Since that time the operation of typing has been subjected to exhaustive studies, including an analysis of over 100,000 running words of typical typing material, micromotion studies of finger and hand motions, and metabolic studies on personal fatigue. On the basis of the new information now available, a new keyboard has been designed with optimum key assignments which it is estimated will result in an additional saving of time, probably greater than any increases in efficiency resulting from foreseeable future mechanical developments in the field.



*Photo, courtesy Boeing Airplane Co.*

The potentialities of Operations Research have only recently been recognized. Its usefulness in business, industry, and the government, is rapidly becoming known. Like all scientific research it is essentially a standard procedure by which a large number of varied problems in many fields may be solved. Its future seems assured—because a great many things that are done in the business, industrial, and government worlds are still at the alphabetic keyboard stage.

## Study Airplane Windshields

STRONGER, ice-free windshields for military airplanes may result from a study of laminated-windshield failure at the Armour Research Foundation.

After studying typical weather conditions, researchers set up laboratory tests duplicating or exceeding these conditions. In one test alcohol, cooled to −90 F, passes across one side of a pane of glass. Heat, supplied by an electric current, is stepped up slowly on the other side until the temperature rises to about 500 F, when the glass breaks.

The researchers found that "cold-soaking" the polyvinyl butyral layer in laminated glass panes may cause the glass to fail. At normal temperatures the plastic is resilient, making it a valuable backing for the more brittle glass. At prolonged low temperatures, however, the plastic contracts and becomes stiff, sometimes cracking the glass and reducing visibility. Another cause of windshield failure may be temperature differential between the center and the edge caused by loss of heat to the cold outer mounting. Heating the mount may answer this problem.

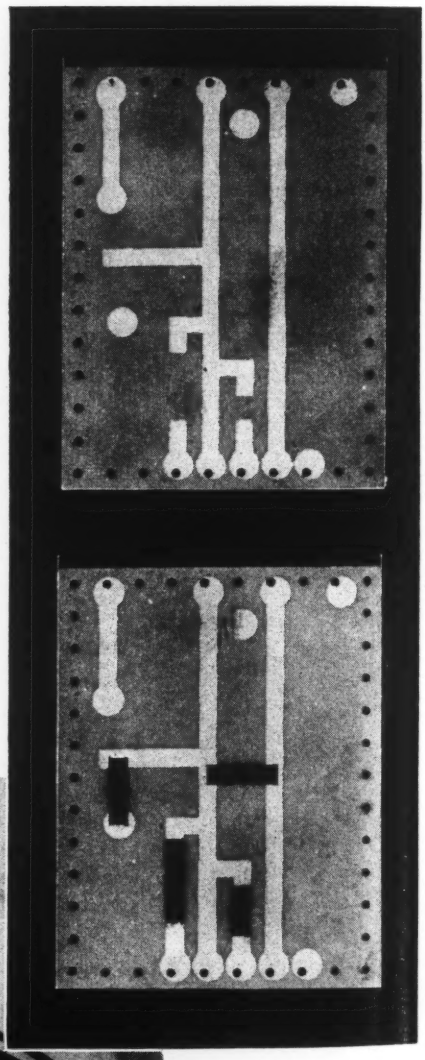
# SCANNING the Field For Ideas

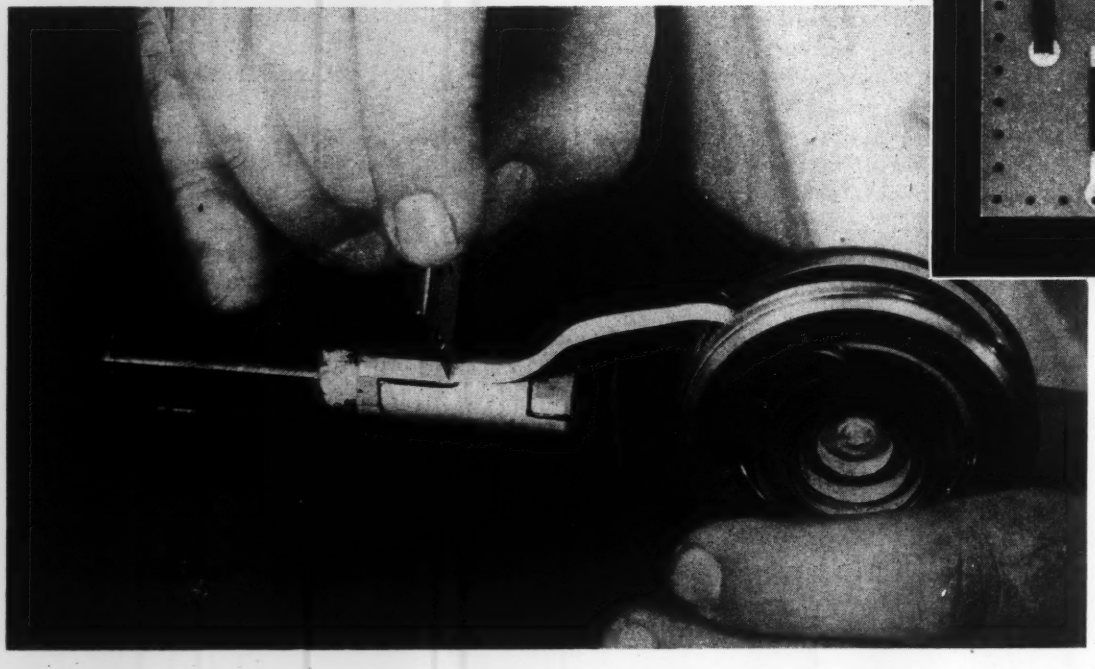
**Adhesive-tape resistors,** having accurately controlled resistance values, are particularly useful for application to printed circuits. They eliminate the variables encountered when the resistance elements are painted or sprayed on a circuit panel. Shown below is a tape resistor being applied to a miniature cylindrical printed circuit chassis. The tape is simply pressed into position, cut to length and cured by baking. No solder or other materials are needed. Another typical printed circuit is shown in the illustration, right, before and after application of adhesive resistors.

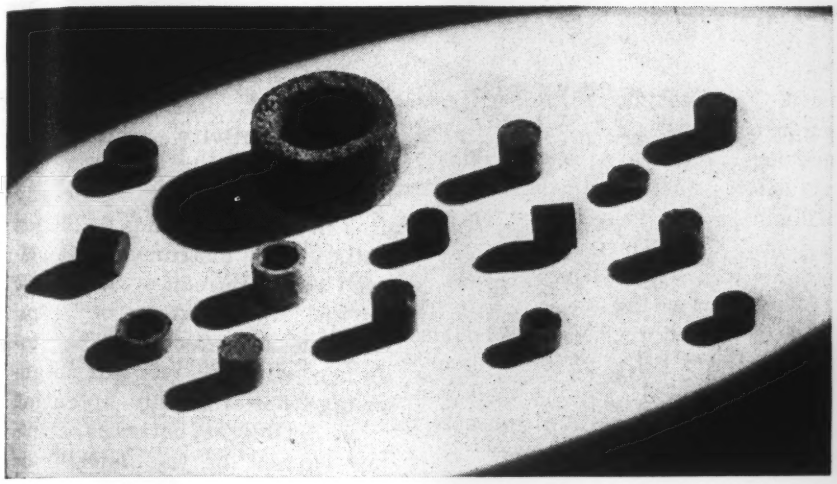
Developed as part of a program of electronic research by the National Bureau of Standards for the Navy Bureau of Aeronautics, the self-adhesive resistors are pressed into standard gaps left in the printed circuit for their use. To eliminate the variations in resistance introduced by inaccuracies in length and width of a resistor strip, the strip is made to an exact width. Resistance of the elements is controlled by the formulation of the deposit on the tape and the length of the circuit gap.

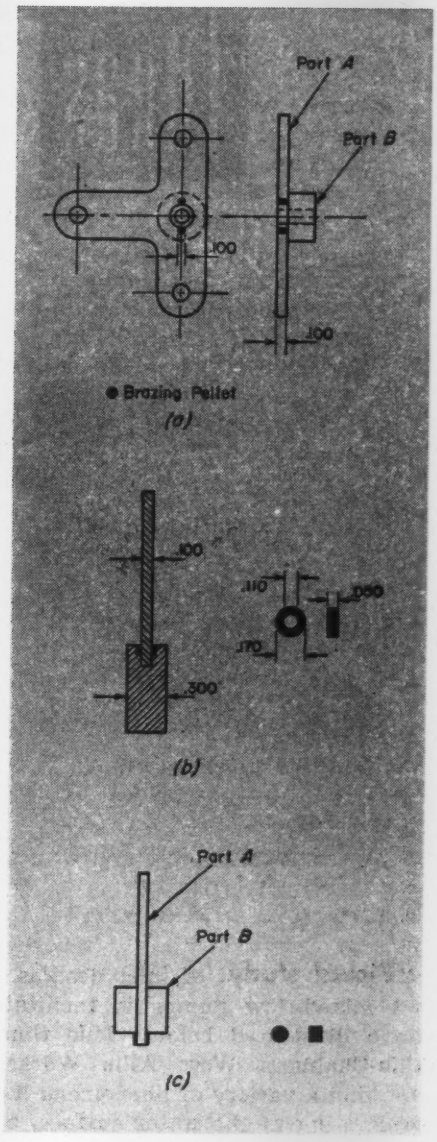
Resistor tapes consist of a mixture of graphite or carbon black, resin and solvent applied in a thin layer to asbestos paper. The resistive coating is sufficiently adhesive to stick to an insulating base plate and to make satisfactory electrical contact with metallic terminals. Silicone resin is used in the binder because of its suitability for high temperature operation. Because of the necessity for curing at high temperatures after the resistors are placed in the circuit, use of this tape is restricted to glass or ceramic base materials. Lower temperature curing resins, however, could be employed for application to some heat resistant plastic bases if operation does not exceed temperature limitations.

Tape resistors made from graphite mixtures have proved remarkably stable at 400 F. Useful range of resistances is between 100 and 5000 ohms. Carbon blacks, which are less desirable at high temperatures, give values from 5000 ohms to 10 megohms.










**Preforms** for brazing or silver soldering, above, contain the proper mixtures of powder metal and flux tailored for each specific job, simplifying production operations and assuring uniformly consistent joints. Developed by PresSint Products, the preforms are compounded and shaped to yield optimum results with flame, furnace or induction heating methods.

As the parts to be joined approach brazing temperature, the flux in the preform begins to melt and becomes active at a temperature lower than the melting point of the alloy. The flux dissolves the oxides and cleans the metal surfaces, enabling the alloy to flow to the desired regions when it melts.

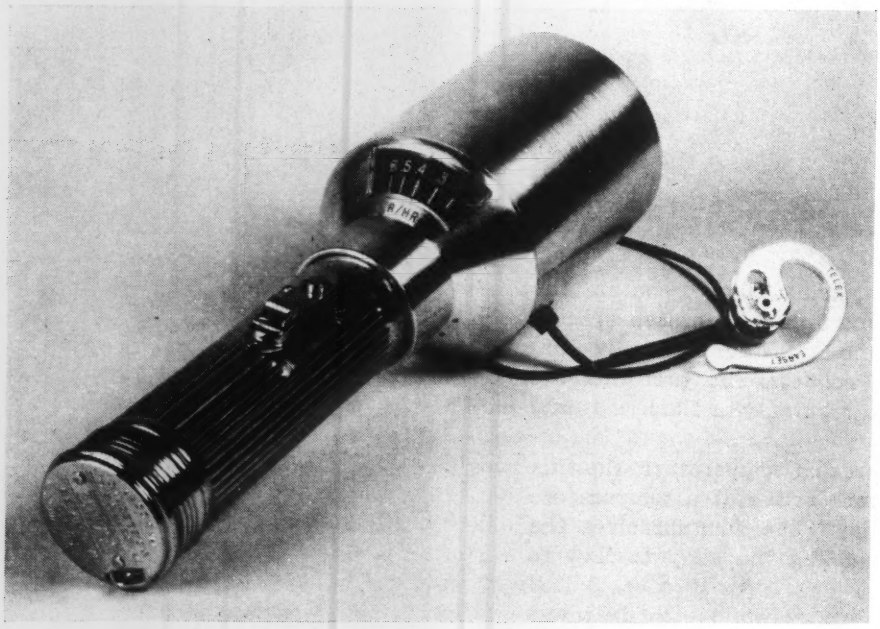
Typical applications for this method are shown in the drawings at right. In sketch *a*, part *A* is a stamping with two additional ears punched in the center hole to provide a well for the brazing pellets. These pellets are dropped into the assembly and, when heated, flow into the joint. Sketch *b* shows the method for joining two parts similar in construction to that of a spark plug. Sketch *c* illustrates a simple method for joining a wire in the well of a cup-shaped stamping. A pellet, whose size is determined by the amount of brazing material required to make a strong bond is placed in the bottom of the well. After heating the wire is pressed into the molten pellet.

**Accurate measurement** of the thickness of thin films has become practical through visual comparison with the step gage, right, developed by Dr. Blodgett in the research laboratories of General Electric. This gage is a specially prepared glass plate on which monomolecular layers (0.1-microinch) of barium stearate are deposited in such a way as to produce strips of increasing thickness across the face of the gage, each succeeding strip being 1 microinch thicker than the preceding one.

When the gage is illuminated by white light each step reflects a color determined by its thickness. These steps, therefore, are seen as a series of colored stripes. Range of the gage illustrated is from 2 to 16 microinches and comparison with any film may be made to determine thickness with an allowance being made for the difference in refractive indexes between the film being measured and the gage.

Comparison may be made with any film that reflects interference colors, such as those that are produced by evaporation, sputtering, plating, etc. The gage may also be employed for indirectly measuring vapor pressures, temper colors on metals and transparent conductive coatings on glass such as on aircraft windshields.

# Ideas

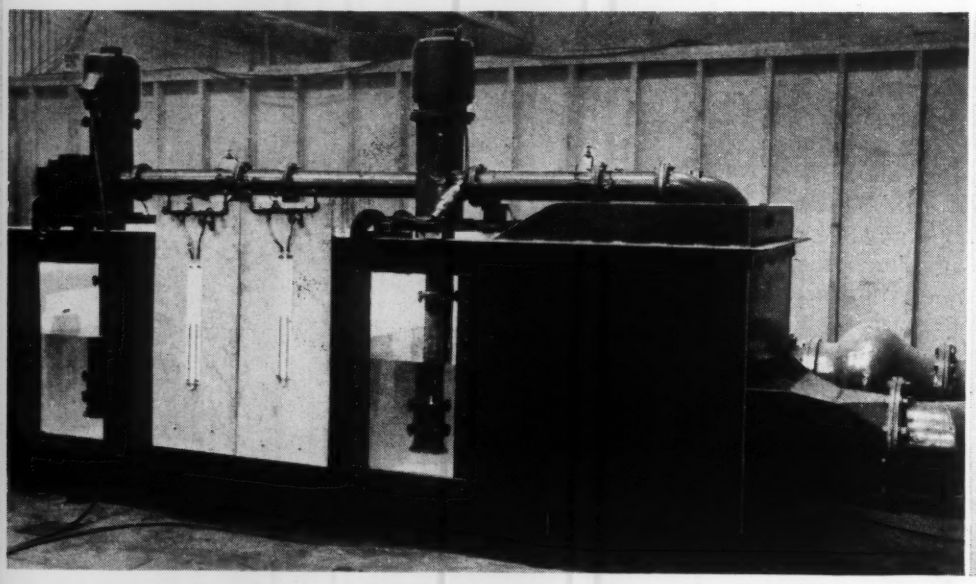


**Instrument,** left, for measuring radioactivity utilizes an electronic circuit to eliminate the microammeter generally used to indicate gamma radiation units. The instrument, developed at the Bureau of Standards for the Navy Bureau of Ships, employs a detector tube together with a vibrator high-voltage power supply operating from flashlight batteries. Output current of the detector is proportional to the incident radiation.

Aural indication method uses a thyratron circuit. If the potential difference between the grid and cathode of the thyratron exceeds the firing potential the circuit will oscillate, producing audible sound. A potentiometer, manually set at the threshhold of oscillation, is a measure of radiation level and is calibrated in mediation units.

**Visual study** of inlet designs for vertical, axial and mixed-flow pumps is facilitated with the test flume illustrated below. This flume, in use at the Allis-Chalmers West Allis Works, permits photographing a variety of phenomena including whirlpools terminating at the water surface, on the sides of the tank, the bottom of the tank, and between the two pumps.

Air drawn into the pump can cause noise, vibration and reduced capacity. Underwater photograph, below, shows a vortex admitting air into the inlet of a vertical pump. The cone at the bottom broke up a second vortex extending to the bottom of the flume. Some of the general solutions to existing problems involve relocation or redesign of channel walls, floors or ceilings; guide vanes for more uniform flow; removal or redesign of obstructing members; baffles at or near the suction bell; floating grids to prevent air from being drawn into the pump; and turning vanes under the suction bell.

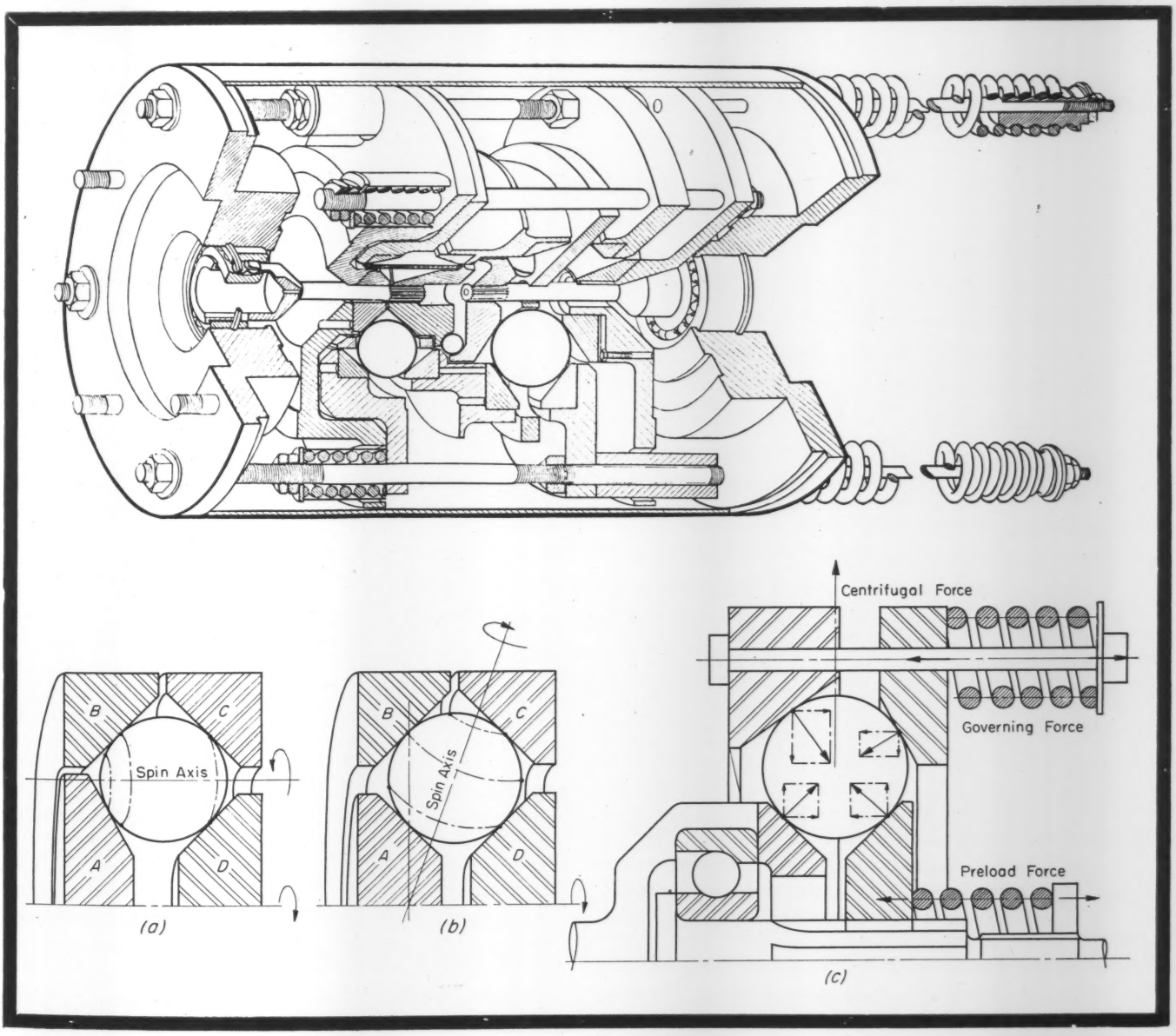


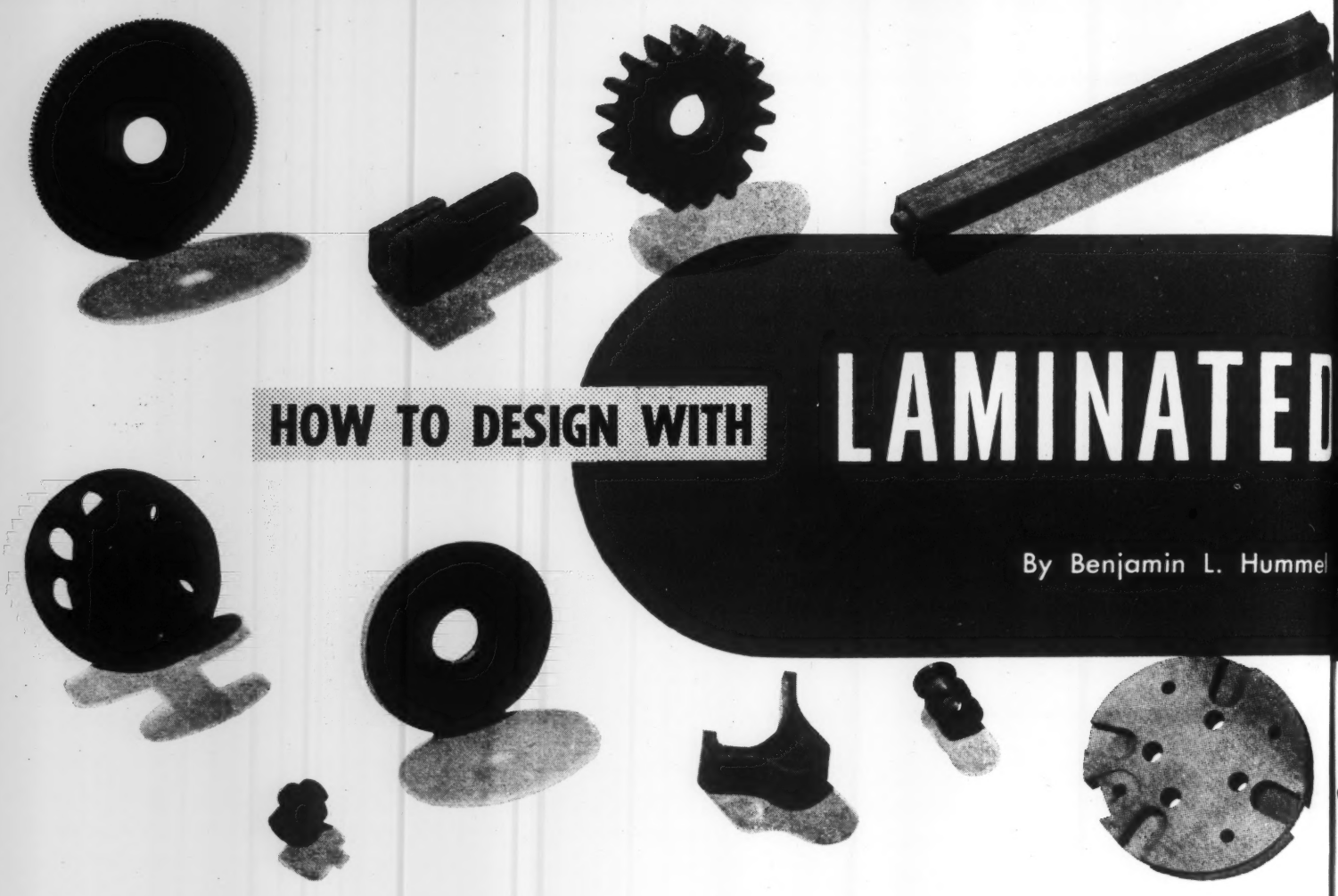
**Self-governing transmission,** below, produces constant output speed regardless of variations in input speed throughout its operating range. For instance, in the particular two-stage transmission illustrated, the output speed remains within plus or minus 1 per cent of 8000 rpm throughout variations in the input speed between 9000 and 15,000 rpm.

Employing rolling balls between cones as shown in sketches *a* and *b*, the transmission may also be used as a fixed-speed reducer or an externally controlled variable-speed unit, depending on the relationship between the cone elements *A*, *B*, *C* and *D*. By choosing different surfaces on the cones or different relative positions between input and output elements, specific speed ratios are obtained. These ratios are constant as long as the balls rotate in a fixed path. Should the balls be moved radially, however, as a result of shifting the axial positions of the cones, new speed ratios would be obtained.

When cone *B* is stationary, inner cones *A* and *D* are input, and cone *C* is output, high reductions are possible. In fact, when *A* and *D* are similar and *B* and *C* are also similar, output speed is zero. By slight modifications of *B* and *C*, ratios of 1000 or more to one are obtainable. Further modifications would give reversed output or range from forward to reverse.

In the self-governing transmission, constant output speed is obtained by utilizing the centrifugal force of the rotating balls. This can be controlled so that, as the balls move out when input speed is increased, the speed ratio increases to maintain a constant output speed. To achieve this speed relationship, the axial movement of the outer cone is controlled by a spring as shown schematically in sketch *c*. Because the governing occurs directly from the driving members, there is no lag nor tendency to hunt. This system was developed by J. J. Gerritsen, chief engineer of Tiltman Langley Laboratories Ltd. in London.





# HOW TO DESIGN WITH LAMINATED

By Benjamin L. Hummel

FROM their inception more than 40 years ago, laminated plastics have grown to a large family of engineering materials with a great range of properties and corresponding applications, *Fig.* 1. The first of these materials were developed for the electrical industry to meet conditions calling for both mechanical strength and good electrical properties. Today, both of these attributes have been highly developed among the many standard and special grades available.

To the designer, one of the most significant properties of plastic laminates is their high strength-weight ratio. These materials, consisting of laminations of a paper or fabric base and a resin binder, approach steel in mechanical strength, weight for weight. Additionally, they offer resistance to many chemicals, possess good bearing properties, and are adaptable to a variety of processes for the manufacture of components. Besides doing yeoman duty in the electrical industry, they are serving excellently as bearings in a great variety of sizes, are being applied to gears, *Fig.* 2, of wide pitch and power ranges, and are finding a multitude of aircraft uses.

Laminates offer sound design possibilities for mechanical components when the characteristics peculiar to these combination thermosetting materials are properly taken into account. Valid under many conditions at any time, plastic laminates are particularly worthy of investigation today as alternates to less available materials.

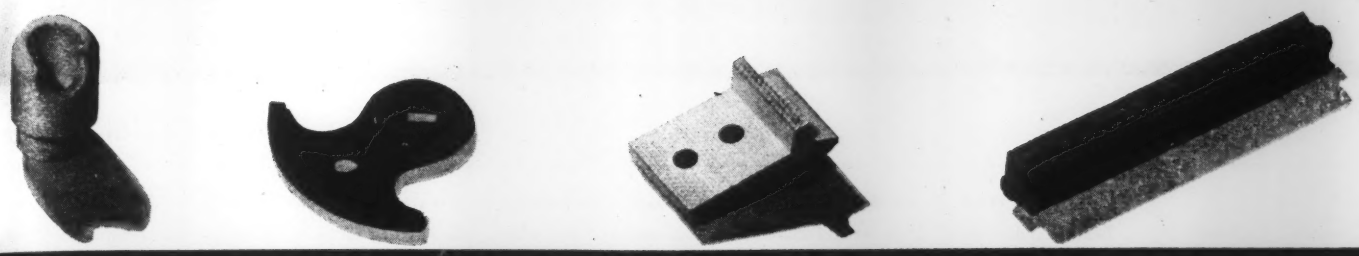
This article is intended to serve as a basis for appraisal of laminated plastics in standard stock forms and to outline some of the fundamentals essential to the proper design of plastic laminate components. The materials themselves, the stock forms in which they are available, and the design rules for adapting them to manufacturing processes will be discussed.

**Laminated Plastics:** High-pressure laminates in their diverse grades display a range of properties analogous to metal alloys. Variations are achieved by selection of the filler of base material and the resin, as well as by control of the manufacturing process. These materials are produced by the application of heat and pressure to layers of paper or fabric that have been impregnated with heat-reactive resin solutions of phenolic, melamine or silicone types.

CONSTITUENTS: Base materials commonly used in high-pressure thermosetting laminates are paper, cotton fabric, asbestos paper and fabric, staple-fiber and continuous-filament glass cloth and mat, and nylon fabric.

Papers are usually alpha or kraft type. Laminates with an alpha base—almost pure cellulose—are not as strong as those with a kraft base but are more resistant to moisture. Paper-base laminates are best where electrical properties rather than mechanical strength are required.

Fine-weave cotton fabric imparts high mechanical strength to laminates. For maximum shock resistance, a canvas base is employed. Gear stock is usual-



# PLASTICS

## for machining, stamping and postforming

Associate Editor, Machine Design

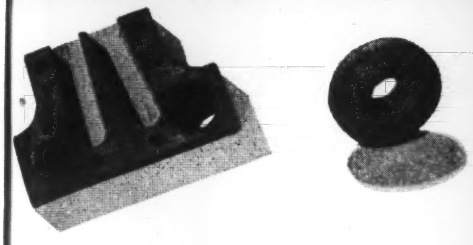


Fig. 1—Above—Typical small machine parts stamped and machined from laminated plastics. Mechanical strength, electrical insulating properties or chemical resistance influenced material selection for these components

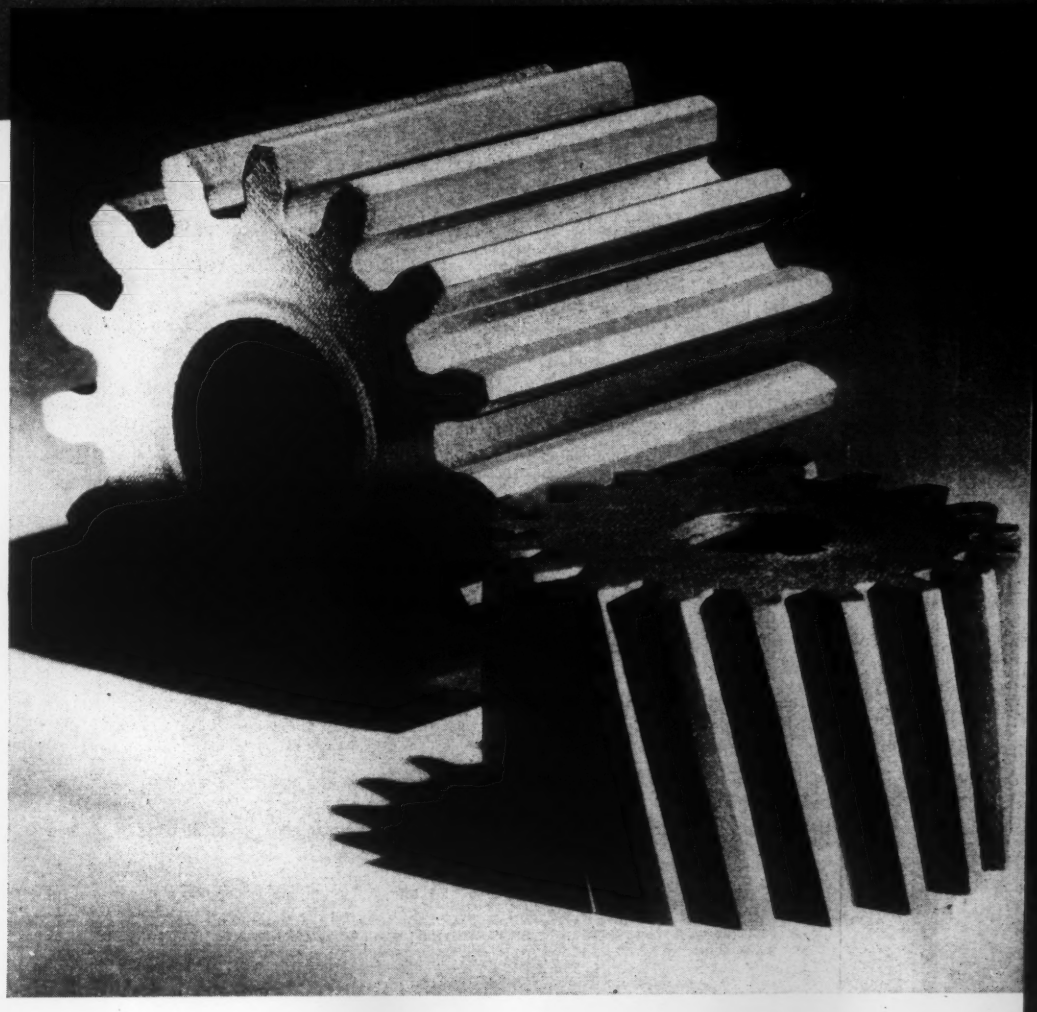


Fig. 2—Right—Silent-operating laminated-plastic gears. Strength, resilience and bearing qualities suit cotton-fabric base laminates for application to light or heavy-duty gears. Under abrasive service conditions, laminates often outlast their metallic equivalents

ly of this type. In general, the cloth-base laminates are the most adaptable to mechanical applications.

Asbestos paper and fabric fillers give greater flame and heat resistance than cellulosic paper and cotton fabric, respectively.

Laminates with glass fabric fillers possess excellent mechanical and electrical properties. Mechanical strength is particularly outstanding when glass fabric is used in conjunction with a melamine resin. The combination of glass fabric and silicone resin offers the best heat resistance of any of the laminates, withstanding continuous service at 400 F.

Nylon-fabric base laminates are poor for mechanical applications but possess excellent electrical properties under high humidity conditions.

GRADES AND PROPERTIES: Shown in TABLE 1 is a summary of properties for the standard grades of laminated plastics. Although these data are appropriate only for sheet, they provide a relative rating for the different grades regardless of form. More

## Table 1 — Properties of Standard

| NEMA and ASTM Grades | Base | Resin | Tensile Strength (psi) | | Tensile Modulus (psi) | | Compressive Strength (psi) | | Min. Flexural Strength[1] (psi) | | Flexural Modulus (psi) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lengthwise | Crosswise | Lengthwise | Crosswise | Flatwise | Edgewise | Lengthwise | Crosswise | Lengthwise | Crosswise |
| X | Paper | Phenolic | 20,000 | 16,000 | 1,900,000 | 1,400,000 | 36,000 | 19,000 | 25,000 | 22,000 | 1,800,000 | 1,300,000 |
| P | Paper | Phenolic | 12,000 | 9000 | 1,200,000 | 900,000 | 25,000 | ..... | 13,000 | 11,000 | 1,200,000 | 900,000 |
| PC | Paper | Phenolic | 10,500 | 8500 | 1,000,000 | 800,000 | 22,000 | ..... | 10,000 | 8000 | 1,000,000 | 800,000 |
| XX | Paper | Phenolic | 16,000 | 13,000 | 1,500,000 | 1,200,000 | 34,000 | 23,000 | 15,000 | 14,000 | 1,400,000 | 1,100,000 |
| XXP | Paper | Phenolic | 11,000 | 8500 | 900,000 | 700,000 | 25,000 | ..... | 14,000 | 12,000 | 900,000 | 700,000 |
| XXX | Paper | Phenolic | 15,000 | 12,000 | 1,300,000 | 1,000,000 | 32,000 | 25,500 | 13,500 | 11,800 | 1,300,000 | 1,000,000 |
| XXXP | Paper | Phenolic | 12,400 | 9500 | 1,000,000 | 800,000 | 25,000 | ..... | 12,000 | 10,500 | 1,000,000 | 700,000 |
| ES-1 | Paper | Melamine or phenolic | 12,000 | 8500 | ..... | ..... | ..... | ..... | 18,000 | 16,000 | ..... | ..... |
| ES-2 | Paper | Phenolic or melamine | 13,000 | 9000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ES-3 | Paper | Phenolic | 15,000 | 12,000 | ..... | ..... | ..... | ..... | 18,000 | 16,000 | ..... | ..... |
| C | Cotton fabric | Phenolic | 11,200 | 9500 | 1,000,000 | 900,000 | 37,000 | 23,500 | 17,000 | 16,000 | 1,000,000 | 900,000 |
| CE | Cotton fabric | Phenolic | 12,000 | 9000 | 900,000 | 800,000 | 39,000 | 24,500 | 17,000 | 14,000 | 900,000 | 800,000 |
| L | Cotton fabric | Phenolic | 14,000 | 10,000 | 1,200,000 | 900,000 | 35,000 | 23,500 | 15,000 | 14,000 | 1,100,000 | 850,000 |
| LE | Cotton fabric | Phenolic | 13,500 | 9500 | 1,000,000 | 850,000 | 37,000 | 25,000 | 15,000 | 13,500 | 1,000,000 | 850,000 |
| A | Asbestos paper | Phenolic | 10,000 | 8000 | 2,500,000 | 1,600,000 | 40,000 | 17,000 | 13,000 | 11,000 | 2,300,000 | 1,400,000 |
| AA | Asbestos fabric | Phenolic | 12,000 | 10,000 | 1,700,000 | 1,500,000 | 38,000 | 21,000 | 16,000 | 14,000 | 1,600,000 | 1,400,000 |
| G-1 | Glass fabric | Phenolic | 12,500 | 9500 | 1,900,000 | 1,100,000 | 50,000 | ..... | 22,000 | 18,000 | 1,800,000 | 1,000,000 |
| G-2 | Glass fabric | Phenolic | 16,000 | 11,000 | 1,800,000 | 1,200,000 | 38,000 | 15,000 | 20,000 | 16,000 | 1,300,000 | 1,000,000 |
| G-3 | Glass fabric | Phenolic | 23,000 | 20,000 | 2,000,000 | 1,700,000 | 50,000 | 17,500 | 20,000 | 18,000 | 1,500,000 | 1,200,000 |
| G-5 | Glass fabric | Melamine | 37,000 | 30,000 | 2,300,000 | 2,000,000 | 70,000 | 25,000 | 50,000 | 40,000 | 1,700,000 | 1,500,000 |
| G-6 | Glass fabric | Silicone | ..... | ..... | ..... | ..... | 40,000 | 9000 | 18,000 | 16,000 | ..... | ..... |
| G-7 | Glass fabric | Silicone | 23,000 | 18,500 | 1,800,000 | 1,800,000 | 45,000 | 14,000 | 20,000 | 18,000 | 1,400,000 | 1,200,000 |
| N-1 | Nylon fabric | Phenolic | 8500 | 8000 | 400,000 | 400,000 | Note 4 | Note 4 | 10,000 | 9500 | 600,000 | 500,000 |

* From *Standards for Laminated Thermosetting Products,* Pub. No. LP1-1951, September 1951, National Electrical Manufacturers Association, New York 17. Values represent averages taken from tests of several laminators and are intended to serve only as a general guide in design. Chemical resistant properties of these standard laminates are as follows:

*Acids:* All grades except G-5 resist dilute solutions of most acids.
*Alkalies:* No grades are recommended for use in alkaline solutions except melamine Grade G-5 which is resistant to dilute alkaline solutions.
*Solvents:* Most grades are unaffected by most organic solvents except acetone which may soften the punching grade stocks. Benzol and toluol may affect silicone Grades G-6 and G-7.

## Laminated Thermosetting Sheets*

| Min. Izod Strength (ft-lb per 1-in. notch) Lengthwise | Crosswise | Hardness (Rockwell M) | Specific Gravity | Thermal Expansion (cm per cm per deg C) | Heat Resistance (Cont. F) | Max. Water Absorption[2] (per cent) | Characteristics and Applications | NEMA and ASTM Grades |
|---|---|---|---|---|---|---|---|---|
| 0.55 | 0.50 | 110 | 1.36 | $2.0\times10^{-5}$ | 225 | 6.00 | General-purpose low-cost grade for mechanical applications though inferior to fabric base grades. Structural parts for electrical equipment, aircraft, etc. | X |
| 0.55 | 0.50 | 95 | 1.33 | $2.0\times10^{-5}$ | 250 | 3.60 | Intended for hot punching. For spacers, terminal boards, spool heads, switch links, etc. | P |
| 0.60 | 0.55 | 75 | 1.34 | $2.0\times10^{-5}$ | 200 | 5.50 | Intended for cold punching and shearing. For panels, washers, switch bases, dials, etc. | PC |
| 0.40 | 0.35 | 105 | 1.34 | $2.0\times10^{-5}$ | 250 | 2.00 | General electrical and mechanical grade with good machinability. For panels, circuit breaker arms, terminal blocks, bobbin heads, etc. | XX |
| 0.45 | 0.40 | 100 | 1.32 | $2.0\times10^{-5}$ | 250 | 1.80 | Better electrical grade than XX and suitable for punching. For electrical components. | XXP |
| 0.40 | 0.35 | 110 | 1.32 | $2.0\times10^{-5}$ | 250 | 1.40 | Excellent electrical grade with good machinability. For radio, X-ray, etc., work at high voltage and high temperature. | XXX |
| 0.35 | 0.30 | 105 | 1.30 | $2.0\times10^{-5}$ | 250 | 1.00 | Better for electrical work than XXX, and more suitable for punching. For terminal boards, switch rotors and stators, etc. | XXXP |
| 0.45 | 0.40 | 118 | 1.45 | $2.0\times10^{-5}$ | 250 | 2.50 | Black or gray surfaces and opaque white core. For engraving name plates, etc. | ES-1 |
| 0.45 | 0.40 | 118 | 1.40 | $2.0\times10^{-5}$ | 250 | ... | Same as ES-1 but with white subcore and black core for toughness in thick sheet. | ES-2 |
| 0.45 | 0.40 | 120 | 1.38 | $2.0\times10^{-5}$ | 250 | 2.50 | Same as ES-1 but with white or gray surfaces and black core. | ES-3 |
| 2.10 | 1.90 | 103 | 1.36 | $2.0\times10^{-5}$ | 225 | 4.40 | Primarily for machine parts. Base is a medium weave and weight cotton fabric. Available in different subgrades with different weight fabric. Heavier fabric gives higher impact strength but rougher machined edges. For gears, pinions, cams, pulleys, bobbin heads, bearings, etc. | C |
| 1.60 | 1.40 | 105 | 1.33 | $2.0\times10^{-5}$ | 250 | 2.20 | Higher resin content and more moisture resistant than C. Tougher than XX for electrical applications. For circuit breaker arms, motor bases, water and steam valve disks, friction disks, etc. | CE |
| 1.35 | 1.10 | 105 | 1.35 | $2.0\times10^{-5}$ | 225 | 2.50 | Primarily for light machine parts or those requiring intricate machining. Fine-weave light-weight cotton fabric base provides finer finish than C but is not as tough. For small gears, pinions, and other machine parts. | L |
| 1.25 | 1.00 | 105 | 1.33 | $2.0\times10^{-5}$ | 250 | 1.95 | Higher resin content and more moisture-resistant than L. Finer appearance and easier machining than CE. For terminal strips, panels, and high humidity applications. | LE |
| 0.60 | 0.60 | 111 | 1.72 | $1.5\times10^{-5}$ | 275 | 1.50 | More flame and heat resistant than paper or cotton-fabric base grades, but difficult to punch and machine and also poor electrically. For armature slot insulation and wedges, electric appliance insulation, etc. | A |
| 3.60 | 3.00 | 103 | 1.70 | $1.5\times10^{-5}$ | 275 | 3.00 | Similar to A, but tougher. For rotor valves, thrust washers, armature slot wedges, caustic-resistant applications, etc. | AA |
| 5.0 | 4.0 | 110 | 1.60 | $1.8\times10^{-5}$ | 290 | 2.70 | Staple-fibre woven glass fabric base. General-purpose grade with good electrical properties but difficult to machine and punch. For armature slot wedges, structural parts requiring good electrical properties, etc. | G-1 |
| 4.5 | 3.5 | 105 | 1.50 | $1.8\times10^{-5}$ | 275 | 1.50 | Same as G-1, but slightly better for electrical applications. | G-2 |
| 6.5 | 5.5 | 100 | 1.65 | $1.8\times10^{-5}$ | 290 | 2.70 | Continuous-filament woven glass fabric base. General-purpose grade with good electrical properties. Mechanically superior to G-1 and G-2. | G-3 |
| Note 3 | Note 3 | 120 | 1.90 | $1.0\times10^{-5}$ | 300 | 2.70 | Continuous-filament woven glass fabric base. Strongest and hardest grade. Good flame resistance; second only to silicone laminates in heat and arc resistance. Difficult to machine and punch. For arc barriers, circuit breaker parts, structural parts requiring good electrical properties under dry conditions. etc. | G-5 |
| 6.0 | 5.0 | 95 | 1.65 | $1.0\times10^{-5}$ | 400 | 0.55 | Staple-fibre woven glass fabric base. Excellent electrical properties, heat and arc resistance. For high-temperature electrical uses. | G-6 |
| 6.5 | 5.5 | 100 | 1.68 | $1.0\times10^{-5}$ | 400 | 0.55 | Continuous-filament woven glass fabric base. Same as G-6 but stronger. | G-7 |
| 3.0 | 2.0 | 105 | 1.15 | ..... | 165 | 0.60 | Excellent electrical properties under high humidity conditions. For high-voltage applications and electrical uses requiring postforming operations. | N-1 |
| Note 5 | Note 5 | | | | | | | |

[1] For $\frac{1}{16}$-inch thick stock. Thicker sheets tend toward somewhat lower values.

[2] For $\frac{1}{16}$-inch thick specimens, 1 inch wide by 3 inches long. Values are higher for thinner sheets, lower for thicker, because of edge effect.

[3] Lengthwise and crosswise values are 6.0 and 5.0 for thickness range $\frac{3}{32}$ to under $\frac{1}{8}$-inch; 7.0 and 5.5, $\frac{1}{8}$ to under $\frac{1}{2}$-inch; and 9.0 and 6.0, $\frac{1}{2}$ to under 2 inches.

[4] Because of high cold flow, compressive strength cannot be measured accurately. Compressive yield strength flatwise is 20,000 psi approx.

[5] Applies only to thicknesses of $\frac{1}{8}$-inch and over.

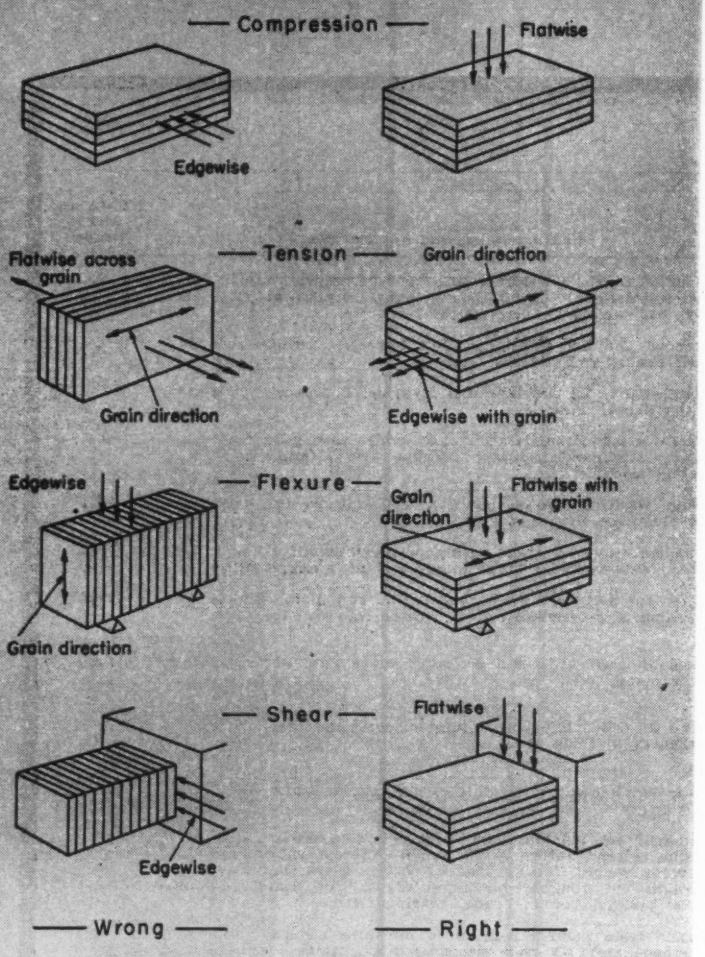



**Fig. 3—Preferred orientation of laminations with respect to loads. Maximum strength of the material can be utilized if stresses act in only the one recommended direction. Otherwise, lower strength limits, Table 1, must be used in design**

extensive standardization and specification data are available for these 23 grades from the National Electrical Manufacturers Association.

Just as TABLE 1 shows that certain grades are outstanding for particular properties, and others represent compromises for dual purposes, so have the manufacturers of laminates developed additional special-purpose grades and cross-bred many combination grades. A few of these grades are as follows:

1. Melamine-resin grades, similar to phenolic paper or fabric types, but possessing greater resistance to heat, flame and arcing
2. Fabric-base grades with resin binders containing uniformly dispersed graphite for low-friction, low-wear applications
3. Laminates of glass fabric and Teflon for heat and chemical resistance and excellent electrical properties. Available, also, with copper foil on one or both surfaces for etching of "printed" circuits
4. Nonwoven cotton mat filler grade with phenolic binder to minimize directional properties, for mechanical applications and easy machining
5. Paper or fabric-base laminates with external or internal layers of natural, Buna-S, Buna-N or neoprene rubber, to obtain sealing action against metal or for mechanical mountings
6. Paper or fabric-base laminates for postforming.

Though not among the minimum number of basic grades standardized by NEMA and ASTM, these additional special-purpose grades are standard with and readily available from one or more of the laminate producers. Variations actually are nearly infinite in number, and producers can compound grades for specific requirements when volume and purpose warrant. However, since available grades are numerous in number and offer a wide assortment of properties, special compounding usually need not be considered.

**Basic Forms:** As with metallic materials, laminated plastics are available in assorted forms and sizes. The most common forms are: sheets; round, square and rectangular tubes; and round rods.

SHEET: In sheet form, material is available generally in any minimum size and up to the sheet size itself, which may be 36 inches by 36 inches, 24 inches by 100 inches, etc., according to the practices of different producers.

**Table 2—Standard Thickness of Laminated Plastic Sheet**

| Range (in.) | Increment (in.) |
|---|---|
| 0.010 to 0.025 | 0.005 |
| 1/32 to 1/16 | 1/64 |
| 1/16 to 1/4 | 1/32 |
| 1/4 to 1/2 | 1/16 |
| 1/2 to 2 | 1/8 |
| 2 to 3 | 1/4 |
| 3 to 10 | 1/2 |

**Table 3—Typical Thickness Tolerances for Laminated Plastic Sheet**

| Nominal Thickness (in.) | Tolerance (in.) Grade X | Grade C |
|---|---|---|
| 0.010 | ±0.002 | ..... |
| 1/16 | ±0.005 | ±0.0075 |
| 1/4 | ±0.012 | +0.030 |
| 1 | ±0.033 | +0.065 |
| 2 | ±0.049 | +0.097 |
| 5 | ..... | +0.190 |
| 10 | ..... | +0.360 |

Minimum thickness of sheets is 0.10-inch for some grades, 1/32-inch for most others. Maximum thickness varies according to probable applications. Some are limited to 1/4-inch or less, many are standard to 2 inches, and some fabric laminates, such as Grade C, are available in thicknesses to 10 inches. Standard thicknesses are available at close increments as shown in TABLE 2.

Thickness tolerances vary with both the nominal thickness and the laminate type. Full schedules of tolerances are given by the NEMA *Standards for Laminated Thermosetting Products* and by laminate suppliers. The partial schedule for paper base Grades X, P, etc., and fabric-base Grade C given in TABLE 3 shows typical values.

TUBES: Two types of tubes are available: rolled and molded. In the manufacture of rolled tubes, layers of resin-impregnated paper or fabric are rolled on a mandrel under heat and pressure and finish cured in an oven. Molded tubing is processed similarly except that the final cure is performed in a mold under heat and pressure. Concentricity and electrical prop-

erties of rolled tubing are generally superior. On the other hand, molded tubing possesses higher moisture resistance and mechanical strength. For pneumatic or hydraulic pressure applications, paper-base tubing is generally preferred over fabric-base materials which often are slightly porous.

These two tube types are not standard for all grades of plastic laminates. Selection is limited according to probable applications. As a rule, those grades intended for mechanical applications are available in one or both tube types.

Round tubing is available in a size range as extensive as that for sheet. Length ranges from 18 inches upward. For many rolled tubes, inside diameters start as small as ⅛-inch and proceed upward to 48 inches. Similarly, outside diameters range from 3/16 to 50 inches. Minimum wall thickness for paper grades is 0.010-inch, for fabric grades 1/32 or 1/16-inch. Maximum ratio of wall thickness to inside diameter is ¼ or ½, depending upon laminate grade. For molded tubes, the schedule is similar except that outside diameter is limited to 4 inches and minimum wall thickness is slightly greater than for rolled tubes.

Many producers also supply tubes of shapes other than cylindrical, such as square, rectangular, elliptical or cylindrical with square, hexagonal, etc., center holes.

RODS: Round rods are supplied in molded and machined forms. Molded rods are simply wound laminations, mold cured. Machined rods are turned from sheet stock and thus show a difference in directional properties not typical of molded rods. Diameters range from a minimum of ⅛ to ¼-inch to a maximum of 2 or 4 inches, according to grade. Molded rods are ground to standard tolerances of ±0.005-inch for diameters from ⅛ to 1 15/16-inch, ±0.008-inch from 2 to 4 inches. Also available from different suppliers are rods of other shapes: square, elliptical, angle, channel, etc.

The greater part of the foregoing data on forms represents "standardized" practice. However, many producers can supply a still greater number of sizes or shapes as regular stock items.

**Colors and Finishes:** The most common color of plastic laminates is "natural," resulting from the undyed color of the ingredients. The phenolic laminates vary in natural color from a light tan to a light or reddish brown. Melamine glass-base laminates vary from a light gray to tan. White to cream

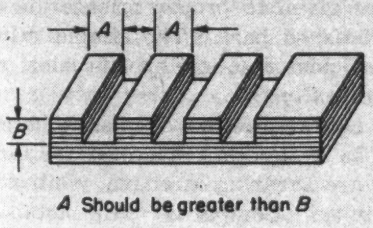



Fig. 4—Recommended proportions for spacing and depth of milled slots

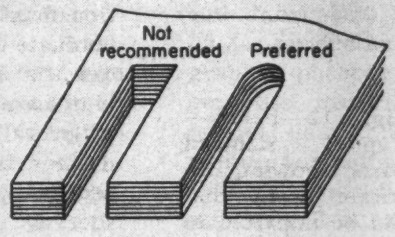



Fig. 5—Preferred end contour of deep slots. If end-milling can be employed, stress concentration is reduced and finishing operations may be simplified

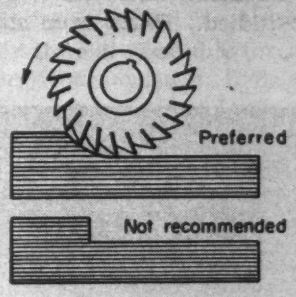



Fig. 6—Profile for blind slotting. Cutter should impart curvature to end of slot. To prevent delamination, climb milling should be practiced

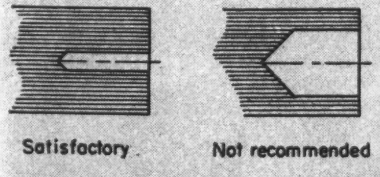



Fig. 7—Holes drilled parallel to laminations. Avoid large holes if any pressure, as from a screw, may tend to separate laminations. Clamping is often necessary during drilling to prevent splitting

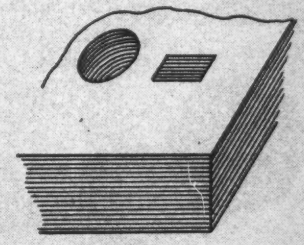


Fig. 8—Irregular holes. Specify only round holes, unless stock is thin enough for punching. Broaching can be performed but only at added cost

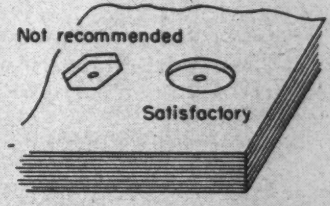



Fig. 9—Counterbores and recesses. For tool simplicity and lower cost, avoid irregular contours

is the inherent color of the silicone glass-base materials.

Some grades are available in black or chocolate color, although these surface colors may not be uniform throughout the laminate. Use of dyes to produce colors is not generally recommended when laminates must endure severe mechanical or electrical service. As a consequence of the deleterious effects of dyeing, engineering grades of laminates are most commonly available only in this limited color range.

All engineering grades of sheet have a natural semigloss finish resulting from the pressing and curing. Additionally, some grades are available polished, others dull. Round tubes and rods have a ground finish as a natural result of their processing, although standard finishes for phenolic tubes and rods include both buffed and varnished. Varnishing enhances electrical qualities to some degree.

**First Design Considerations:** Specification of any material for a particular application must proceed from knowledge of many factors which include requirements of the expected service, production volume, properties of the material, and its processability. Only on such a basis is application of laminated plastics justified. The following discussion highlights some of the significant factors that should be taken into account.

Decision to use stock forms of laminated plastics will be most effective if alternate possibilities are also studied. Parts from stock forms usually cannot be produced at the high rates typical with other high-pressure reinforced plastics. Comparisons should be made with molded-laminate or molded-macerated plastics. Tooling costs, quantities, size and shape, and material properties enter such a study.

High strength-weight ratio of these materials fits them admirably for many applications—if stiffness is not critical. With a modulus of elasticity about one-thirtieth that of steel, laminated plastics deflect significantly more than metallic engineering materials. This quality, while it may eliminate laminates from some applications, is an outstanding virtue in others. Partly because of their resilience, laminated plastic gears, *Fig.* 2, in severe service often have a life many times that of metallic counterparts. Laminates possess good damping qualities and should be considered for use where noise and vibration must be reduced.

Bearing properties of laminates are also quite favorable. Large heavy-duty bearings show long life with water as the only lubricant. Phenolic-fabric laminate with the end grain bearing the load is being successfully used for way surfaces of large machine tools.

As noted in TABLE 1, laminates resist moisture and many chemicals. In this respect, laminated plastics may well be equivalent or superior alternates for less corrosion-resistant or more strategic metals.

When one or another of the laminated plastics appears to be the best answer for a particular job from the standpoint of necessary properties, careful attention must next be given to proper orientation of the laminate in the finished part. The simple principles essential in the efficient and safe specification of laminates are detailed in *Fig.* 3.

Several other characteristics of plastic laminates deserve thought as designs are planned for different processes. They are shearing strength, resilience and thermal conductivity. Compared with metals, laminates usually have lower shearing strengths. This factor often is not of direct significance in design,

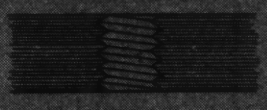


Fig. 10—Above—Preparation of holes for tapping. Because of rough surface, punched holes should be shaved or reamed to insure sound threads

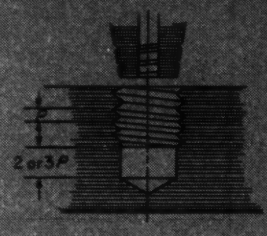
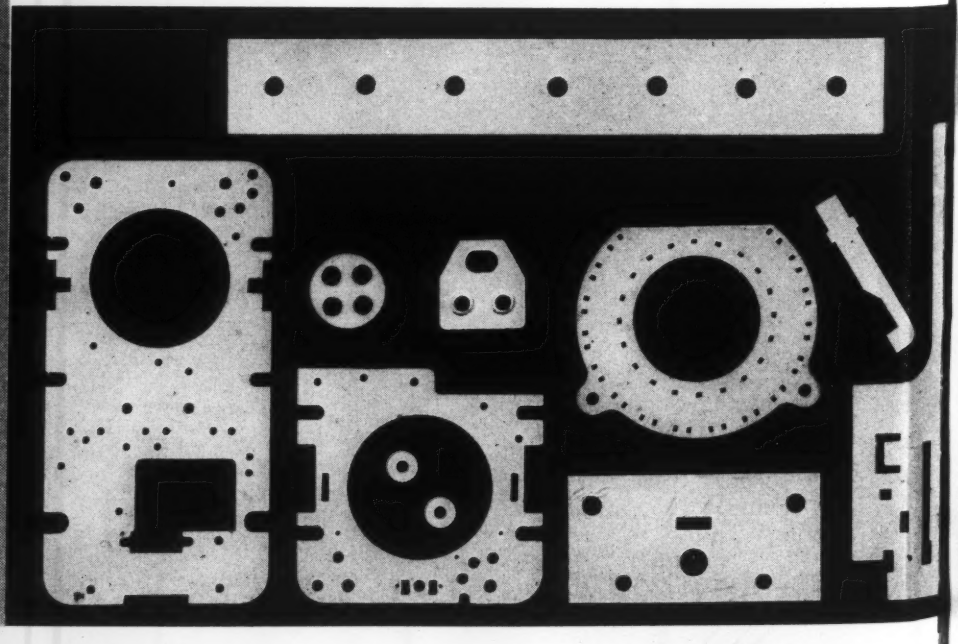



Fig. 11—Above—Tapping blind holes. Clearance equivalent to two or three threads should be provided for the tap at bottom of drilled hole. Otherwise, threads may be stripped or the laminate split

Fig. 12—Below—Typical stamped parts showing intricate detail that can be imparted to thin laminated plastic sheet



but it does influence production facilities and techniques and their effect upon final cost. Because of low shearing strength, laminates can be processed on lighter-weight equipment, in fact, on many machines that are standard for woodworking. Often, low shearing strength also means that operating speeds of machines can be increased greatly, giving correspondingly higher production rates.

Besides influencing selection of a laminate for functional purposes in many applications, inherent resilience of the material affects both the type of tooling required and the control of critical dimensions. During machining and punching, laminates tend to deflect away from the tool and then spring back. For reasonable dimensional accuracy and good surface finish tools must be sharp. Even so, fidelity experienced with tools in metal working cannot be approached. Usually however, tool settings or punch diameters can be so established as to compensate for resilience of the material. Tool maintenance is important, for dulling of tools produces dimensional changes at a more rapid rate in laminates than in metals. With such inherent dimensional variations, fear might be felt about obtaining press fits with laminates. Actually, no difficulty arises since resilience of the material permits assembly with interferences of 0.005-inch or more.

Compared with metals, plastic laminates have low thermal conductivity. As a consequence, heat generated by the machining process may burn the work or the tool unless air or liquid coolants are used. Air is usually preferred. Often the answer lies in carbide tools which withstand high-temperature service better than other cutting metals. Such tools, through longer service before sharpening, can also minimize the problem of dimensional control arising from tool wear and material resilience.

**Design for Machining:** Rules governing the functional loading of the laminate component, *Fig.* 3, are also applicable to the machining of the part. Any action tending to separate the laminations should be avoided. Despite this disadvantage, as compared with the relative freedom from unequal directional characteristics in homogeneous materials, laminates can be worked successfully by many processes. However, successful machining is possible only if these processes are adequately anticipated in the design of the part. The rules are simple and can usually be followed without compromise.

Practically any machining process common in wood or metalworking can be employed in the fabrication of components from plastic laminates. They include sawing, turning, milling, planing, drilling, tapping and threading. Illustrated in *Figs.* 4 to 11 are some of the fundamental rules of design for machined laminate components. They are supplemented by the following discussions which deal with most of the common processes.

CUTTING FROM STOCK: Parts can be cut from laminated plastic stock by sawing. Versatility of band saws may be utilized for cutting paper and cotton-fabric laminates if close tolerances and smooth edges are not important. Circular metal saws give somewhat better dimensional control and finish. Carbide-tipped saws are needed for the harder grades, and thin abrasive wheels are almost a necessity for cutting asbestos and glass-base grades.

With standard metal squaring shears of the guillotine type, laminates may be trimmed up to 1/16-inch thickness for paper-base and ⅛-inch for fabric-base. Heating the stock raises these limits slightly. Where edge finishing is needed, several methods later described can be employed.

TURNING: No difficult problems are posed by turning operations if tool angles common for brass are used. Regular tool-steel cutters are suitable for paper and fabric-base phenolics, but carbide tools give higher production rates, are better for melamine and graphite-phenolic laminates, and are required for glass-base materials.

MILLING AND PLANING: Several of the rules for milling laminates are depicted in *Figs.* 4 to 6. Deep slots can be milled if side milling cutters are used; otherwise, laminates bind on the cutter. Again, carbide cutters are recommended for best results with both planing and milling. If possible, the design of laminate parts should obviate milling at right angles to the laminations, since "delamination" or splitting may result. When right-angle milling cannot be avoided, as in milling or hobbing of gears, a rigid

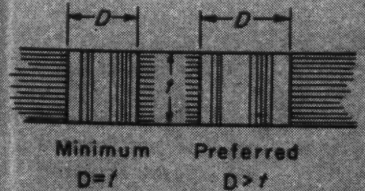



Fig. 13—Diameter of punched holes. Danger of punch breakage is reduced if hole diameter exceeds stock thickness

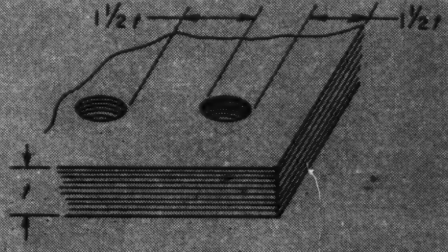



Fig. 14—Spacing of punched holes. Minimum safe distance between holes or between hole and edge varies with the laminate grade. Delamination may occur if spacing is too close

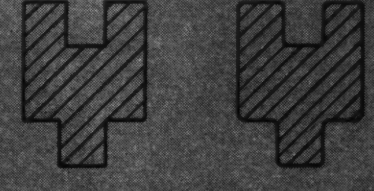



Fig. 15—Blanked corners. If sharp corners are necessary, they can be obtained without delamination by shaving after blanking

## Some Producers and Tradenames of Laminated Plastics

Consolidated Water Power & Paper Co. ..... Consoweld
Wisconsin Rapids, Wis.

Continental-Diamond Fibre Co. ....Dilecto
Newark, Del. Celoron

Fabricon Products Inc. .....Phenopreg
River Rouge, Mich. Phenrok

Farley & Loetscher Mfg. Co. .....Farlite
Dubuque, Iowa Farloex

The Formica Co. .....Formica
Cincinnati, O.

General Electric Co., Chem. Div...Textolite
Pittsfield, Mass.

Mica Insulator Co. .....Lamicoid
Schenectady, N. Y.

The National Plastic Products Co..Nevamar
Odenton, Md.

National Vulcanized Fibre Co. ...Phenolite
Wilmington, Del.

Richardson Co. .....Insurok
Melrose Park, Ill. Plastok

Rogers Corp. .....Lamorok
Manchester, Conn.

St. Regis Paper Co. .....Panelyte
New York, N. Y.

Spaulding Fibre Co. .....Spauldite
Tonawanda, N. Y.

Synthane Corp. .....Synthane
Oaks, Pa.

Taylor Fibre Co. .....Taylor Phenol Fibre
Norristown, Pa.

Westinghouse Electric Corp. .....Micarta
East Pittsburgh, Pa.

backing plate must be used to support the work.

DRILLING: As recommended in *Fig.* 7, drilling parallel to the laminations should be avoided if possible. Drilling in this direction without splitting the material generally requires that the stock be clamped over the length of the drilled hole. When through holes are drilled perpendicular to the laminations, chipping is likely to occur as the drill breaks through. This trouble can be eliminated by the use of an added plate in jigs or fixtures for the drill to enter as it passes through the laminate.

Often, drills larger than the required finished size must be used to compensate for the resilience of the material. Alternatively, drill tips can be ground off-center so that drills cut larger holes and, additionally, bind over less area. Special drills are available for working plastics and give better results than regular drills for metal. Carbide-tipped drills are almost mandatory for asbestos and glass-base grades.

Irregular holes, *Fig.* 8, should be avoided unless the part is thin enough to permit punching. Similarly, irregular counterbores and recesses, *Fig.* 9, are troublesome, requiring special tools or extra operations.

TAPPING AND THREADING: Recommendations on tapping are illustrated in *Figs.* 10 and 11. For both interior and exterior threading, Unified coarse-thread series with class 2A and 2B fit are best. Tap drilling should allow for 70 to 75 per cent of full-depth engagement. Usually best results are obtained with tap drills 0.002 to 0.005-inch larger than used in metal. Chamfers should be specified around the edge of the hole to be tapped or cylinder to be threaded. Such relief minimizes lifting of the material during tapping and, for threading, assures a sound first thread. As for drilling, tapping parallel to laminations requires the extra precaution of clamping the material to avoid the danger of delamination.

The pull-out strength of a screw and tapped hole can be estimated from the empirical equation $F = kdls$, where $F$ = pull-out force, lb; $k$ = factor dependent upon material; $d$ = outside diameter of thread, inches; $l$ = length of threaded engagement, inches; and $s$ = average flatwise shear strength of material, psi. For fabric-base Grade C, $k$ is in the neighborhood of 0.55—0.70. Actually, because elongation of the screw perpendicular to the laminations tends to split the material, failure may arise from delamination rather than from overloading in true shear.

Where it can be conveniently specified, a through screw and nut type of construction is preferable to the screw and tapped-hole type. Self-tapping fasteners of several types are ideally suited to laminates. An almost absolute fit results, and the tapping operation is eliminated.

Fig. 16—Assortment of postformed aircraft parts showing variety of possible shapes and sizes

**Punching, Shaving, Broaching:** Laminated plastics can be pierced and blanked, *Fig.* 12, to thicknesses of about ⅛-inch, although above 1/32-inch some grades must be heated. For smoothest edges, stock should be heated regardless of thickness. To offset resilience of the material, piercing punches must be 0.002 to 0.003-inch larger for each 1/32-inch thickness than the required finished size. Similarly, blanking dies should be 0.001 to 0.008-inch smaller, depending upon thickness. These factors vary with the laminate grade and are best determined by simple advance trials with the selected material.

Punches and dies should fit with minimum clearance. Usually, therefore, punches and dies suitable for metal cannot be used. Either the punch or the die of a set originally intended for metal must be replaced if laminates are to be successfully punched or shaved.

Heating of thicker stock for punching introduces another variable of some concern. Depending upon grade, distances between points on the laminate while cooling shrink 0.002 to 0.010-inch per inch. For relatively precise work, trials should be made with samples to determine the exact compensation required and heating of the stock should be closely controlled preparatory to punching.

Recommended proportions of punched holes and their spacing as well as some details about blanking are illustrated in *Figs.* 13 to 15. Shaving can be easily performed in laminates to provide smoother edges free from checking. Most grades can be shaved cold to ⅛-inch thickness, hot to ⅜-inch. A minimum of 1/32-inch should be trimmed per shave.

Broaches, much like those used with brass, can be employed to produce holes of irregular shapes in laminated plastics. For holes perpendicular to laminations, the work must be supported by a brass or steel plate which has a slide fit with the last cutting tooth of the broach. This provision, and clamping of the stock for broaching parallel to laminations, prevent chipping and splitting.

**Table 4—Minimum Bend Radii for Postforming Laminated Plastics**

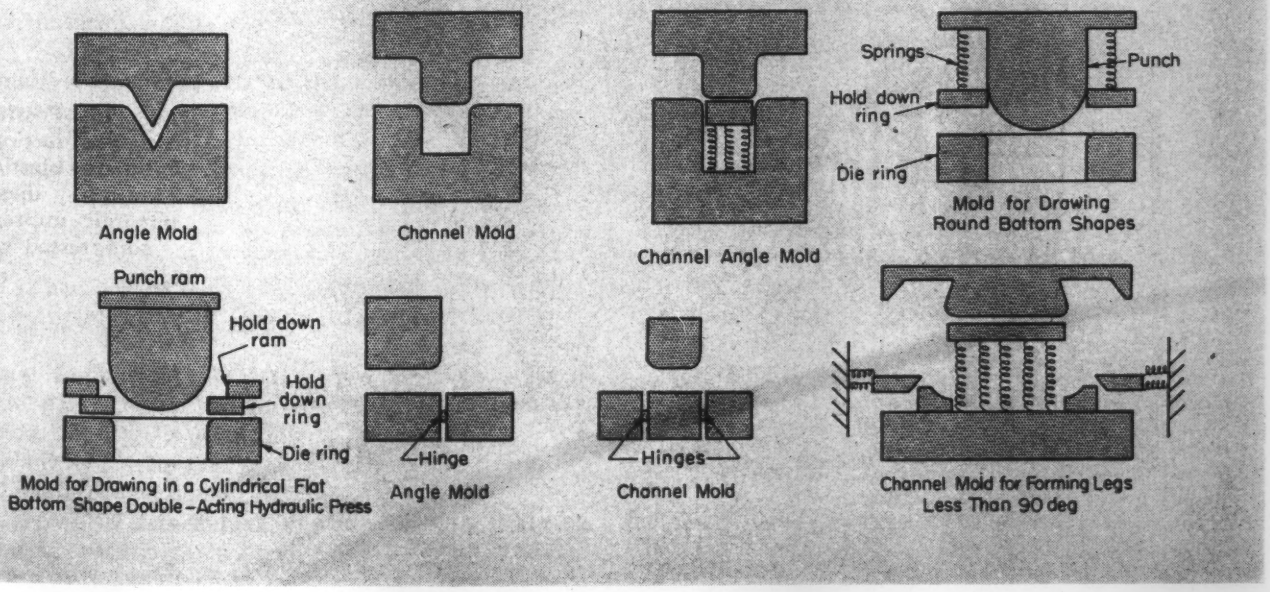
| Sheet Thickness (in.) | Minimum Radius (in.) Fabric Base | Paper Base |
|---|---|---|
| 1/64 | .. | sharp |
| 1/32 | .. | 1/16 |
| 1/16 | 1/16 | ¼ |
| ⅛ | ¼ | ½ |
| ¼ | 1 | 1¾ |
| ⅜ | 2 | 3½ |

**Postforming and Drawing:** A relatively new development in laminated plastics, the technique of postforming is rapidly extending the range of useful applications of laminates, *Fig.* 16. Postforming consists of: (1) heating the cured laminate sheet to obtain flexibility and pliability; (2) shaping, bending, or drawing the heated sheet in molds or fixtures; and (3) retaining the sheet in its new shape during cooling and rehardening of the binder.

All plastic laminates may be formed and drawn to some degree, although the filler material and the binder greatly influence permissible deflection. For example, only simple bends and shallow draws can be imparted to high-pressure glass-base laminates. On the other hand, manufacturers of laminated plastics have developed special cotton-fabric and paper base grades which can be successfully bent and drawn to a significant extent. For most mechanical applications, the best postforming laminates are similar to cotton-fabric base Grade C and paper base Grade XX.

Recommended minimum bend radii for different

Fig. 17—Various types of molds for postforming laminated plastics



thicknesses are given in TABLE 4. These data are representative for special postforming grades. As a rule, grades not especially developed for postforming must be formed with larger radii than those listed. Depths possible in drawing the postforming grades are suggested by the following data: drawing depth for 1/16-inch stock in a 3-inch spherical cup is 1⅝ inches for cotton-fabric base stock, 1¼ inches for paper base stock.

Type of forms that can be executed and the molds or fixtures required are suggested in *Fig.* 17. Within limits, forming and drawing of laminates are similar to such processes for metal. Forming and drawing require pressures of 50 to 100 psi which can be applied by various types of presses or even hand-operated clamps. Postforming of an intricate channel section is illustrated in *Fig.* 18.

Heating temperature required for postforming ranges from 300 to 500 F. Various methods for applying heat can be employed. They include use of ovens, hot plates, infrared lamps, high boiling point liquids, and low melting alloys.

**Surface Finishing:** Laminated plastics can be readily ground, sanded, tumbled, buffed and if required by unusual applications, painted. Grinding with abrasive wheels of various grits and compositions can be performed to attain accuracy in dimension as well as required surface finish. Recommendations of manufacturers should be obtained with respect to wheels especially suited for plastics.

Sanding, with grits ranging from 40 to 240, is often the most effective method of facing or shaping surfaces, roughening material preparatory to painting or gluing, and removing burrs and sharp edges from parts.

Fuzz and burrs peculiar to machined laminated plastic parts can be removed to some extent by tumbling. Various effects on surface finish can be achieved with different tumbling materials. Buffing is effective for giving a high polish to laminate parts. Rouge is an aid in achieving a brilliant finish.

Plastic laminates may be painted, preferably with synthetic lacquer applied by spraying, dipping or brushing. The lacquered part must then be baked at about 275 F. Water absorption of laminates can be reduced by the use of commercial primers and sealers, but baked finishes usually give greatest moisture resistance and best appearance.

**Conclusion:** When application of plastics to mechanical components is considered, attention often is first focused on the more commonly known materials and processes of plastic molding. Molded plastics have earned a rightful popularity in return for advantages supplied. However, laminated plastics and the more prosaic processes of machining, stamping and forming should not be overlooked in the initial appraisal. Through superior properties, production economy in certain quantity ranges, or unmatched suitability in size and form, laminated plastics offer positive design opportunities that merit investigation.

MACHINE DESIGN acknowledges with appreciation the cooperation of the following companies in the preparation of this article:

Bakelite Div., Union Carbide and Carbon Corp. . . . . New York, N. Y.
Continental-Diamond Fibre Co. . . . . Newark, Del.
The Formica Co. (*Figs.* 1, 12, 16, 18) . . . . Cincinnati, O.
General Electric Co., Chemical Div. . . . Pittsfield. Mass.
Synthane Corp. (*Figs.* 4-11, 13-15) . . . . . Oaks, Pa.
Taylor Fibre Co. (*Fig.* 2) . . . . . Norristown, Pa.
Westinghouse Electric Corp. (*Figs.* 3, 17) . . . . . East Pittsburgh, Pa.

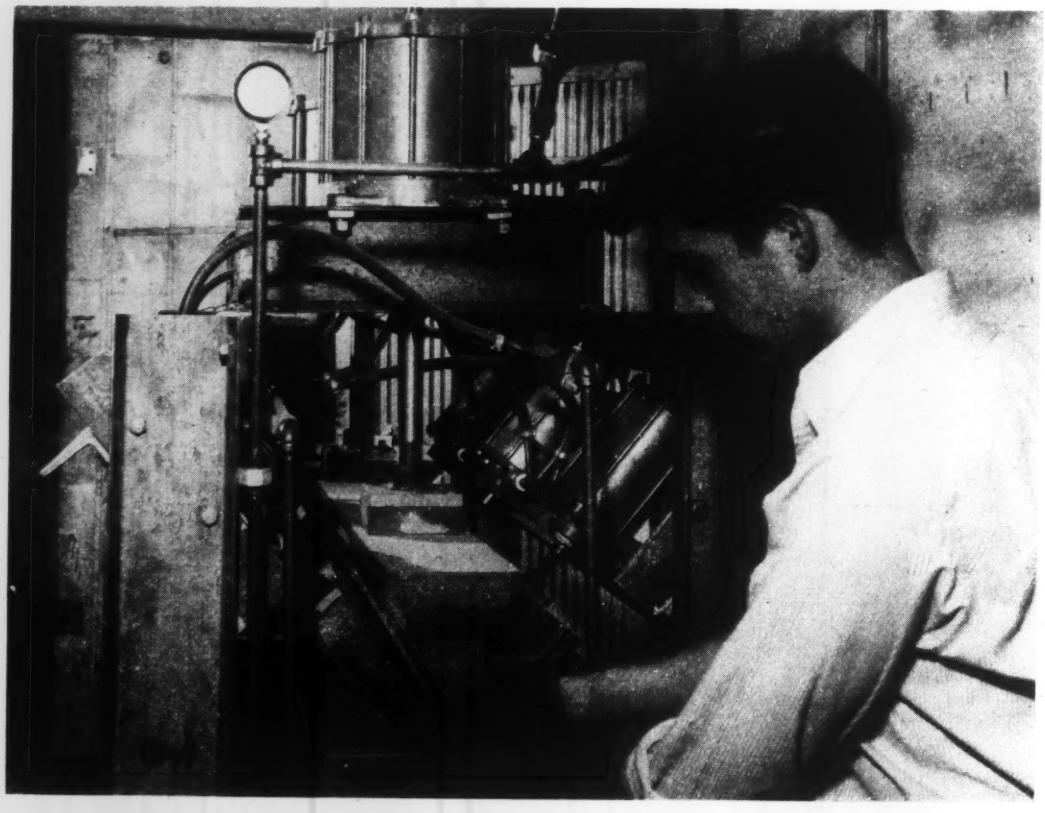


Fig. 18—Postforming a channel section from laminated plastic sheet. Forming dies are phenolic-impregnated compressed wood

# Solving the Thermal Problem for Enclosed Gear Drives

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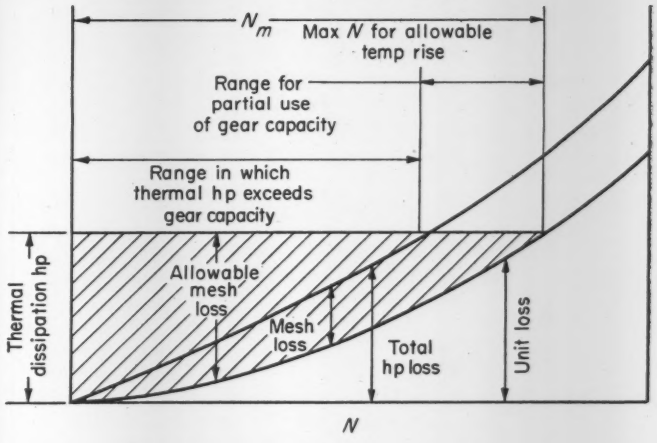



Fig. 1—Allowable gear mesh loss vs speed, showing maximum speed for allowable temperature rise

GEARED power transmitting devices are recognized for their high efficiencies which are usually over 98 per cent for a single-reduction gear train. However, under certain circumstances heat is developed which cannot be dissipated sufficiently rapidly by normal convection or conductance to prevent harmful temperature rises.

Little information is available to guide the designer in estimating the thermal capacity of splash lubricated enclosed gear units. Auxiliary external cooling and lubricant circulating equipment is expensive and, naturally, should not be used unless necessary.

The main sources of heat are frictionally developed in the rotating bearings, meshing gear teeth and circulating lubricant. Many variables are involved which complicate the calculation of frictional resistance, heat dissipation and temperature rise, thereby requiring the acceptance of approximate solutions. This article presents data useful in determining the thermal capacities of enclosed gear drives as well as information which can be utilized to reduce frictional losses.

**Thermal Limitations:** Heat energy is transferred from the gearcase to the atmosphere primarily by convection, slightly by radiation, and normally a certain amount by conduction dependent upon the mounting and shaft connections. Inherent thermal dissipation therefore is determined by the dimensions, design and operating environment of the case. The basis for a rational thermal limitation is the thermal dissipation, $P_t$, of the case which can be expressed in horsepower as:

$$P_t = \frac{RA_e(t_1 - t_2)}{2550} \text{ horsepower}$$

where $R$ is the dissipation rate, BTU/sq ft/deg F; $A_e$ is the effective exposed area of the case, sq ft; and $(t_1 - t_2)$ is the temperature rise, deg. F.

The dissipation rate varies from 2.5 to 5.5 depending upon operating conditions. Higher values are obtained on small units where some heat conduction to the mounting is obtained and air flow is to some extent accelerated by rotating couplings and shafts. Case area is the effective case surface area exposed to free air flow and having an active flow of oil against the inner surfaces.

Allowable temperature rise is governed by the protection desired for the gears and bearings along with

the requirement for adequate lubricant life. Temperature rises of between 50 and 100 F with a maximum ambient of 90 F have been utilized. A temperature rise from 50 to 70 F is considered within good general practice.

**Thermal Horsepower Capacity:** It is possible to formulate the allowable mechanical horsepower which can be transmitted by the meshing gear teeth without exceeding the thermal limitations. This allowable transmitted mechanical horsepower is called *thermal horsepower capacity*. The variation of losses with speed are shown in *Fig.* 1. A speed $N_m$ exists above which the unit losses (bearings, churning, windage, etc.) exceed the thermal dissipation horsepower, hence no mesh loss or transmitted horsepower is allowable for the limiting temperature rise. From $N_m$ to the intersection of the total loss curve partial rated AGMA durability horsepower is permissible. Obviously, the allowable mesh loss is the thermal dissipation horsepower less the no-load horsepower loss and it increases as the speed decreases.

The same conditions arise with change in ratio and the allowable gear mesh loss for thermal considerations is:

Mesh hp loss = Thermal dissipation − Unit hp losses

Unit losses consist of the bearing, oil churning, windage, etc. The variation of permissible mesh loss with speed and ratio are graphically illustrated in *Fig.* 2.

* Wellauer, E. J.—"The Thermal Problem of Enclosed Gear Drives," paper presented before the American Gear Manufacturers Association, October, 1951.

It is evident that the thermal horsepower capacity is governed by the following:

1. A maximum speed $N_m$ exists above which no "pay-load" can be carried without exceeding the allowable temperature rise
2. A minimum gear ratio for a given speed exists below which no "pay-load" can be transmitted
3. The thermal horsepower capacity increases as the speed decreases
4. The thermal horsepower capacity increases as the ratio increases
5. The allowable thermal horsepower for a given case is dependent upon the unit losses in the bearings, oil churning, etc.

**Solving for the Thermal Horsepower Capacity:** Data necessary for the formulation of a thermal horsepower equation have been presented previously* and the solution is easily made as follows:

1. Obtain the basic thermal factor $K_1$ from *Fig.* 3
2. Obtain the thermal speed-ratio factor $K_2$ from *Fig.* 4

Then:

$$\text{Thermal horsepower capacity} = K_1 K_2$$

This formula is for single reduction units in which the thermal problem is more often encountered. Double reduction units can be approximated as to their thermal horsepower capacity by using $K_1$ and $K_2$ for the low-speed center distance and low-speed pinion rpm and multiplying the computed thermal horsepower capacity by 0.40.

Triple reduction units are conventionally free of

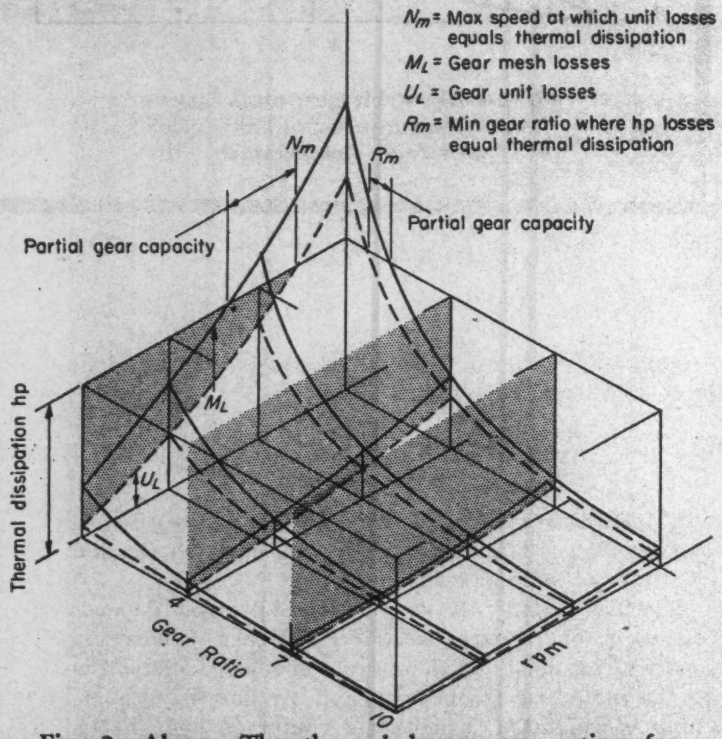



**Fig. 2—Above—The thermal horsepower rating for gear units plotted in three dimensions, representing gear ratio, speed and thermal dissipation**

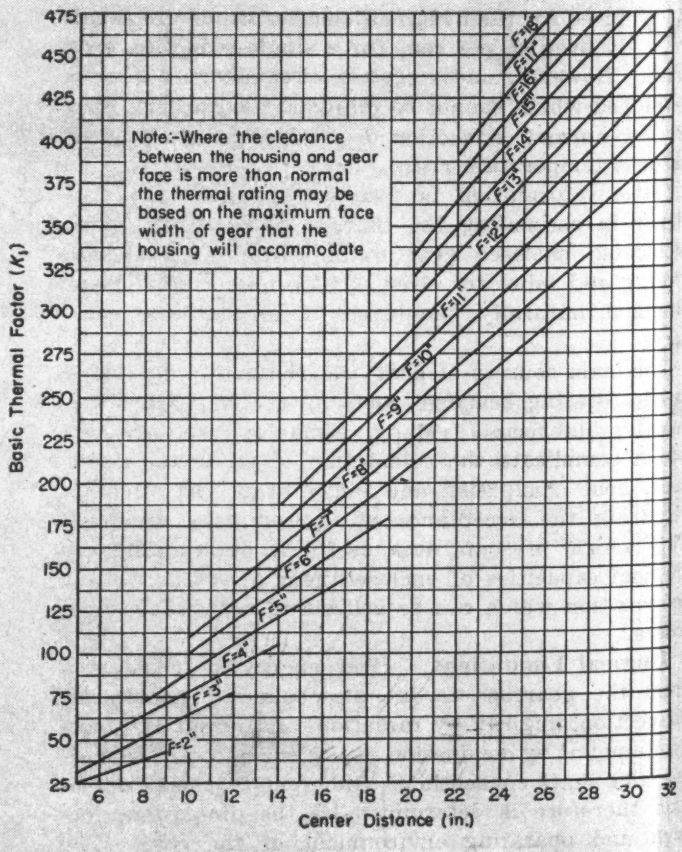



**Fig. 3—Right—Basic thermal factor $K_1$ for single-reduction units for various center distances and face widths**

any thermal problem and accordingly need not be seriously considered by the designer.

Computed thermal horsepower capacity can guide further detailed design considerations. If a considerable safe margin exists, the design of bearings, lubrication, etc. need not be critically examined for excessive losses. If the expected transmitted horsepower equals or exceeds the computed thermal horsepower capacity, then further design considerations are necessary.

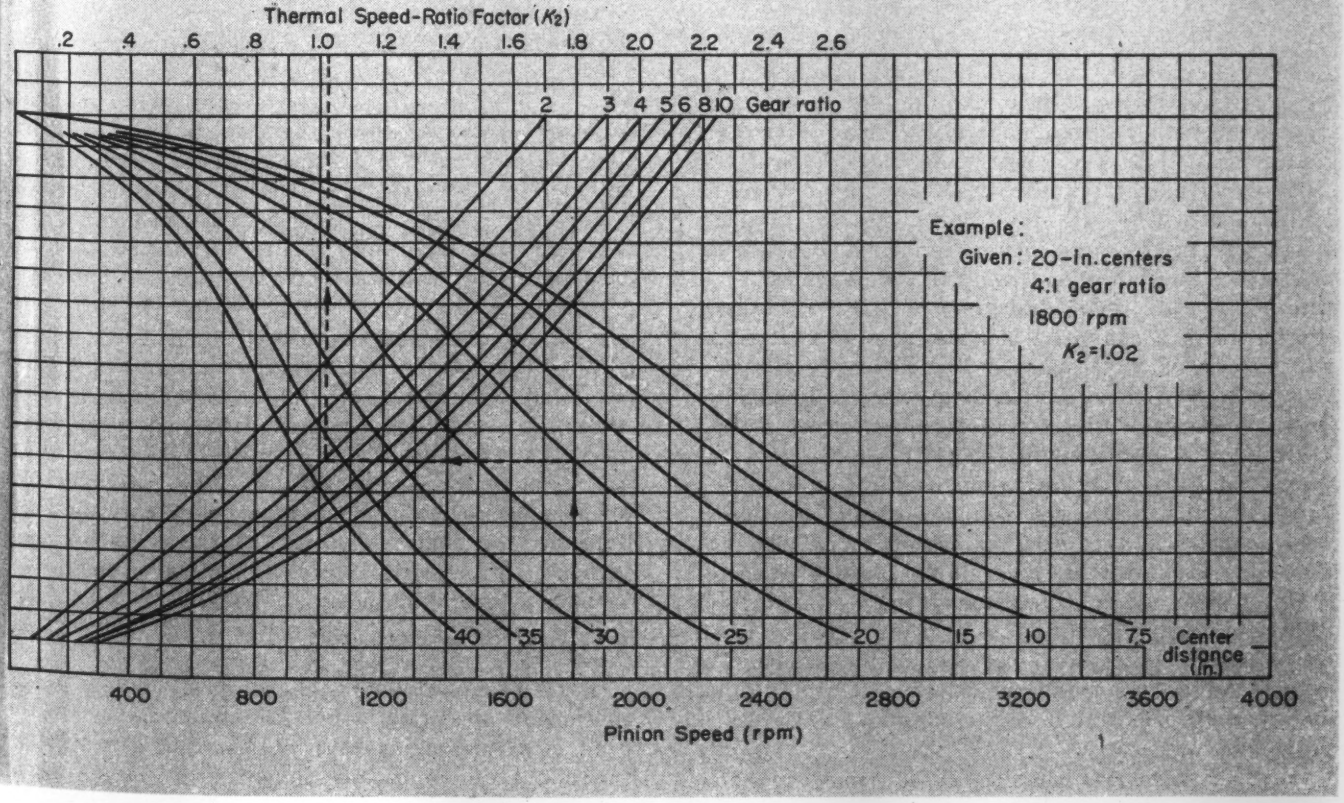
LUBRICANT CIRCULATION LOSS: Power is required to deliver the lubricant from the sump to the gear mesh and bearings. Because of its simplicity, reliability, and economy "splash lubrication" is preferred. Conventionally, in a splash lubricated system, the low-speed gear is submerged in the oil bath and, during rotation, centrifugal force scatters or splashes the oil to predetermined areas where the oil is collected in troughs and distributed to points of lubrication. For extremely slow speeds, oil is picked up by the rim of the low-speed gear and removed by scrapers which in turn deliver the oil to distributing troughs. The development of an adequate splash system requires careful design considerations of mechanical problems which are not of present interest except insofar as they are related to the thermal problem.

As might be expected, a gear rotating through an oil bath can quickly heat the oil and gearcase to a temperature beyond allowable limits. The churning loss is proportional to the submerged gear area and varies approximately between the square and the cube of the pitch-line velocity. The amount of dip should therefore be decreased as the speed increases. Clearance between the side of the case and the rim of the gear should be ample to prevent excess heating by viscous pump action. Also, the clearance to the end of the gear case must be sufficient otherwise the lubricant will "pile-up" and increase the submerged area.

Necessity of maintaining a required volume of oil in the sump limits the amount that the oil level in the case can be reduced. When this condition is reached, an effective solution lies in using an oil pan. Such a pan usually consists of a simple sheet-metal enclosure which separates the gear from the oil in the sump, *Fig.* 5. In the bottom of the pan a number of orifices are drilled which limit the flow of oil to the minimum amount necessary for proper lubrication. For enclosed gear units with conventional clearances and sump volumes, good practice indicates the value of oil pans for pitch-line velocities exceeding those shown in *Fig.* 6, otherwise an increased sump depth is necessary to allow a sufficiently low oil level for minimum gear dip while maintaining an adequate volume of sump oil.

BEARING LOSSES: If the thermal horsepower capacity is approached and the pinion speed exceeds 2000 rpm or the maximum journal velocity exceeds 20 fpm, the bearing design will merit attention. At these limits the bearing losses can be a major source of frictional heat. The high-speed bearings are par-

**Fig. 4—Thermal speed-ratio factor $K_2$ determined from gear ratio and center distance**



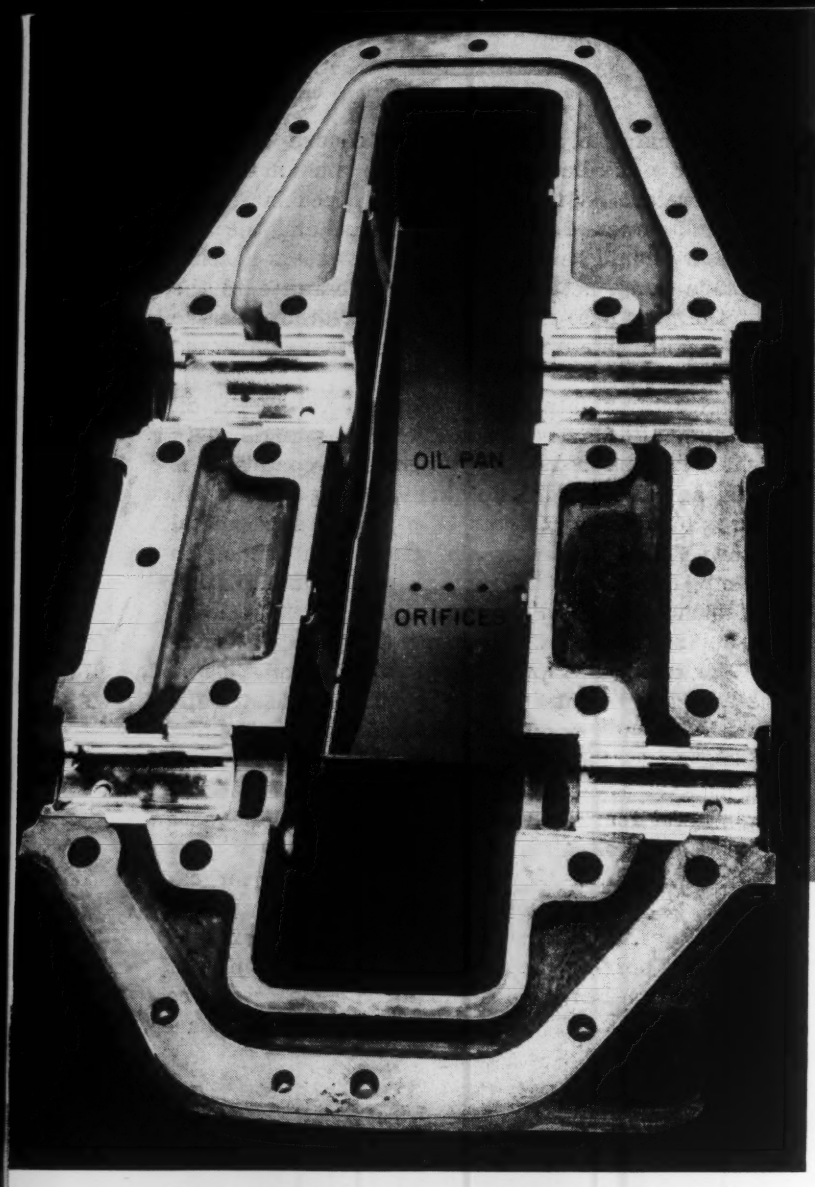



Fig. 5—Typical gear case oil pan showing orifices to limit oil flow

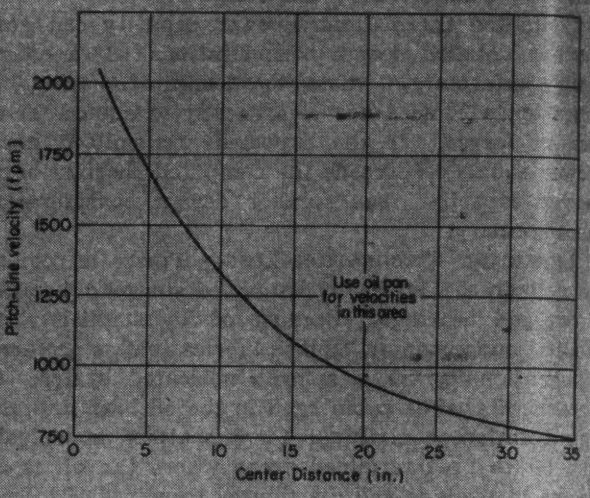



Fig. 6—Above — Recommended pitch line velocities for oil pans

Fig. 7—Right—Water jacket oil cooler built in cover of gear unit

ticularly important. It is not unusual to find that the area immediately adjacent to the high-speed bearings is operating at a temperature rise 15 to 20 F greater than that of the sump and case. This is not particularly harmful if the maximum temperature is maintained within the safe limits for the bearing metal. If no overhung or other extraneous loads exist, the journal diameters can be designed to a minimum. Effects of diameter, velocity, clearance, etc. on the efficiency of a bearing are well covered in other literature which can be utilized to advantage.

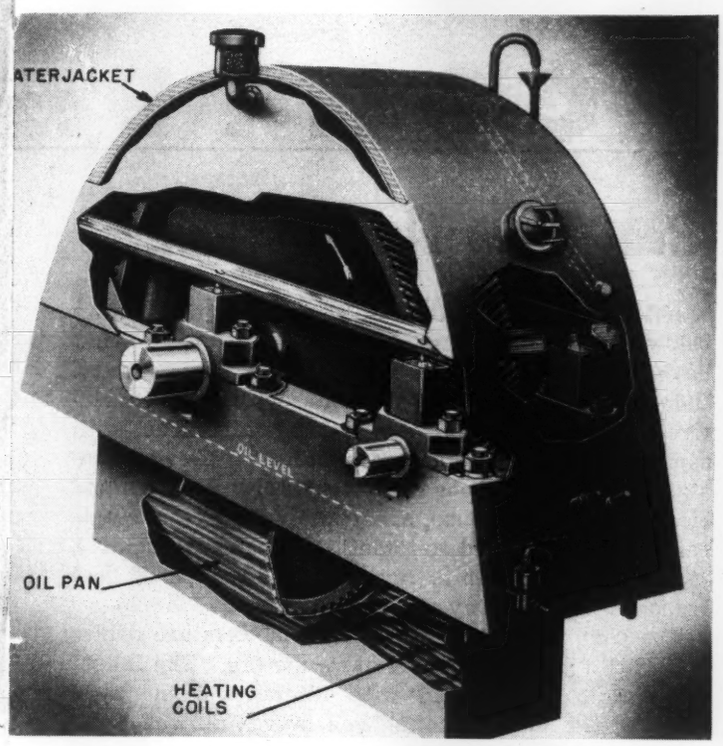
GEAR MESH LOSS: Action of gear teeth during the engaging period results in a combination of sliding (as high as 35 per cent of the pitch-line velocity) at the extremities of action to pure rolling at the pitch line. Developed stresses which the lubricant must resist can be in the order of 80,000 to 300,000 psi. The phenomena which enables lubricants to successfully operate under these conditions has not been fully explored. Research is difficult because mesh losses range from ¼ to 1 per cent of the transmitted power and actual direct measurements are difficult and accurate separation of the effects of variables is practically impossible.

Mesh friction loss should follow some mode between solid metal contact and film lubrication. At the present time this seems true and the mesh loss appears to vary as the square root of the pressure per inch of face width and the square root of the pitch-line velocity.

Inasmuch as the function of the gear teeth is to transmit the load, the tooth and blank design necessary to complete this function at the most economical proportions leaves but little latitude for considerations of loss.

TEMPERATURE RISE: The computed thermal horsepower capacity allows a temperature rise of 50 – 70 F which can be used for average commercial conditions. Adverse locations, where the case is in an enclosed space or covered with fine material such as in cement mills and ore processing equipment, will cause greater temperature rises. If the designer has control over the operating environment and is assured that the expected conditions will be maintained, a higher temperature rise might be satisfactory. Ambient temperature plus the temperature rise must maintain the maximum oil temperature within safe limits. A maximum oil temperature of 180 to 200 F can be used under some circumstances provided that satisfactory protection is afforded the gear teeth by the operating viscosity of the lubricant and that maximum film temperature of the bearings is below the allowable limit for the bearing metal. As the operating temperature of the oil is increased, greater attention is necessary to provide adequate backlash, proper bearing clearances, etc. to accommodate the thermal expansions.

Closely coupled motors, turbines or hot processing equipment operating above the temperature of the gear unit can conduct heat into the gear case through the shafts, couplings, and mounting plates. Applica-




tions such as these require an additional investigation of temperature rise conditions.

The thermal dissipation horsepower can be increased proportionately to the temperature rise. If design studies, tests or experience indicates that changes in proportions, reduced oil levels, decreased lubricant viscosities, increased sump capacity, etc. do not control the temperature rise within desired limits, it is then necessary to resort to auxiliary cooling.

AUXILIARY COOLING: Additional cooling may be provided simply by having a large sump located away from the gear unit. The disadvantage of this system is the cost and quantity of oil necessary to provide satisfactory results.

Water jackets can be built into the cover as shown in *Fig.* 7. This system is simple and can provide a 20 F drop in temperature with a moderate supply of water. Splashing oil draining or dripping from the cover is cooled effectively and is directed into troughs for delivery to the bearings. Note the wells which fill with oil to provide simple, cool lubrication for the bearings. The oil pan has a slide valve control to regulate the amount of oil admitted. Additional coils for heating the oil are sometimes used in the bottom of the case for low-temperature starting conditions.

Also, a water jacket can be placed in the base. Heat absorption rates of 70 to 100 BTU/hr/deg F (oil temperature—mean water temperature) can be secured. Since the velocity is not as great in the base and stagnant areas might exist, the base jacket must be more carefully designed than the cover type cooler for maximum effectiveness. Reductions in temperature rise of from 10 to 20 F are obtained with a water jacketed sump using 2 to 10 gpm of water. For either the cover or base coolers, care must be exercised to prevent air locks otherwise much of the value of the system is lost because it cannot carry off the heat.

Multiple fins on the housing exterior can be of value but these usually are not sufficiently effective to justify the additional expense. Increasing convection by means of a fan of moderate air-flow capacity may have advantages. If conditions are proper, a drop in temperature rise of 10 to 20 F can be secured.

EXTERNAL COOLERS: Any of the commercial types of oil coolers allows sufficient latitude to control the temperature rise, within desired limits, merely by selecting a sufficiently large cooler. A lube circulating pump is required and along with this it is only natural to provide pressure lubrication to the bearings and a spray for the gear mesh. Dipping the low-speed gear is then unnecessary, and a source of heat is thereby eliminated.

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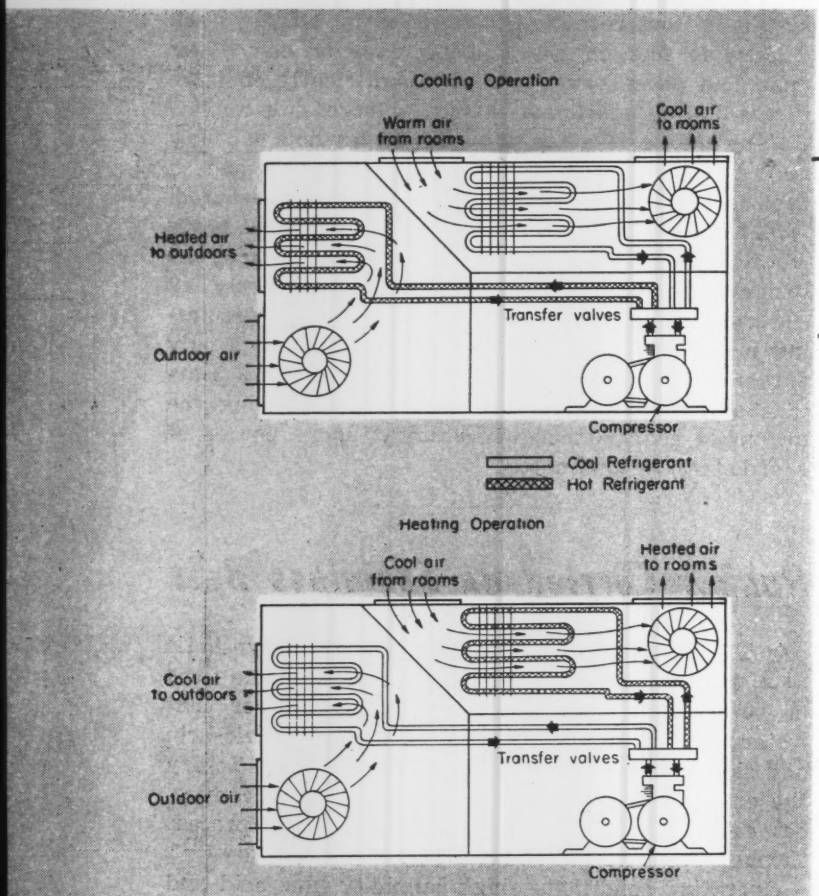
## Rubber Carried on Stainless Belt

AT ONE stage in its manufacture, GR-S synthetic rubber emerges from the processing in the form of "crumb," a latex containing about 30 per cent water along with a certain amount of sulphuric acid and salt not completely removed by washing. To dry the crumb for shipment, inclined heavy-duty conveyors carry it from the washing and filtering process through ovens held at about 175 F.

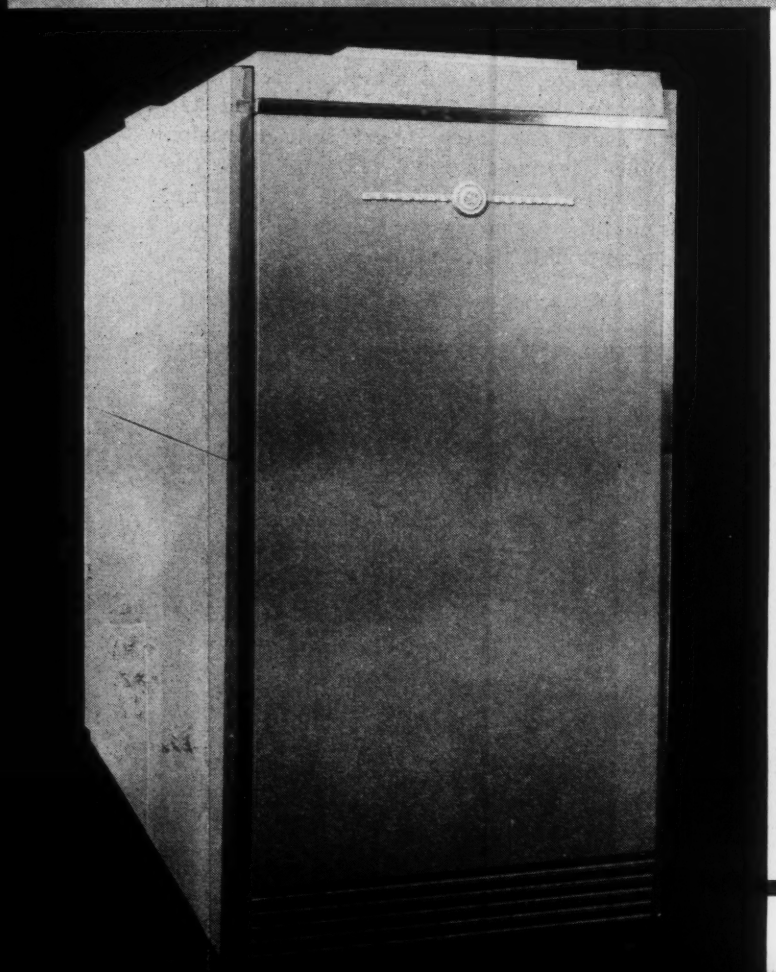
Operating conditions—high humidity plus acid and salt—played havoc with standard black-iron conveyors used at this point in the U. S. Rubber Company's plant at Port Neches, Tex. To correct these difficulties, stainless steel conveyors were recently installed. The new conveyors (of which there are eight in the plant) each consist of 173 hinged flights or sections of perforated 16-gage, type 316 stainless steel. The sections are approximately 12 inches long and 115 inches wide. Plant engineers report that corrosion and maintenance headaches are over, and that the baling and shipping procedure has been speeded up, since the dried product no longer sticks to the conveyor and plugs up plate perforations.

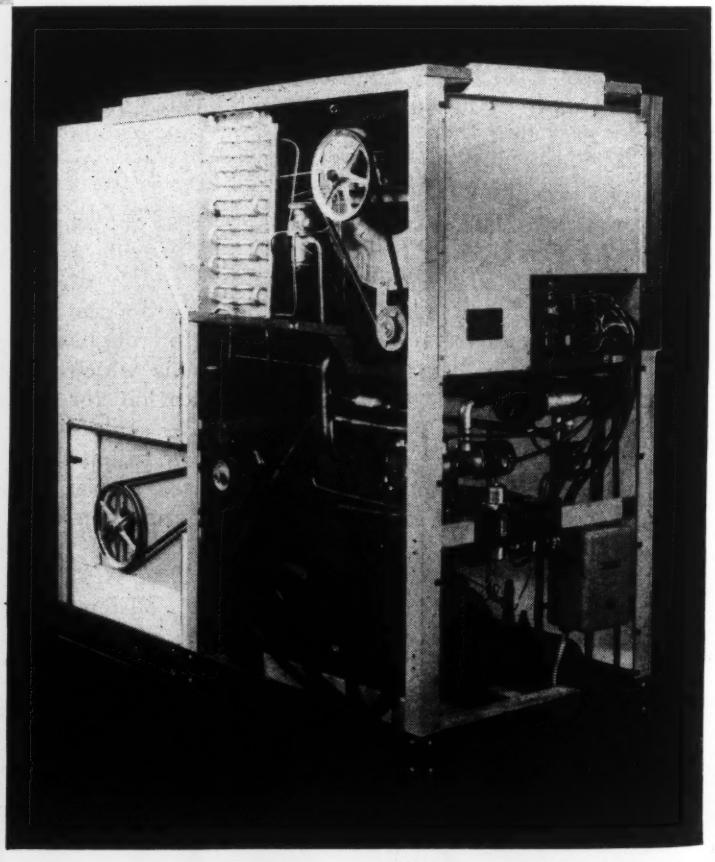



# Heat Pump Elements Unified

COMPACT construction of the heat pump shown below combines, in one package, components that have proved thoroughly successful in similar duty. Indoor and outdoor compartments, with their respective coils, are built into one housing in contrast with separate coil and compressor units in previous installations. Compressor equipment, control valves and electrical controls also are contained in the single cabinet. Year-round automatic temperature control, including switchover to reverse the direction of heat transfer, is completely automatic.

The compressor and centrifugal blowers are driven by V-belts from individual drive motors. The indoor air circuit is equipped with filters, and in warm weather the indoor cooling coil serves also as a dehumidifier. Approximately, the performance factor is said to be three heat units transfer to one heat unit equivalent in power input. This ratio varies, depending on the temperature of the outside atmosphere. Diagramatic sketches, left, show the alternate refrigerant circuits of the General Electric packaged heat pump. Net weight of the 3-hp unit is 1140 lb; the 5-hp unit weighs 1500 lb.





# Circle Shear also Spins Flanges

DUAL-PURPOSE metalworking machine illustrated has been designed for highspeed shearing and flanging operations on circular steel disks and heads such as are used in boilers, drums and tanks. A rack and pinion arrangement aids in positioning the center bearing arm for various work diameters. Scale graduations on the bed indicate the arm setting.

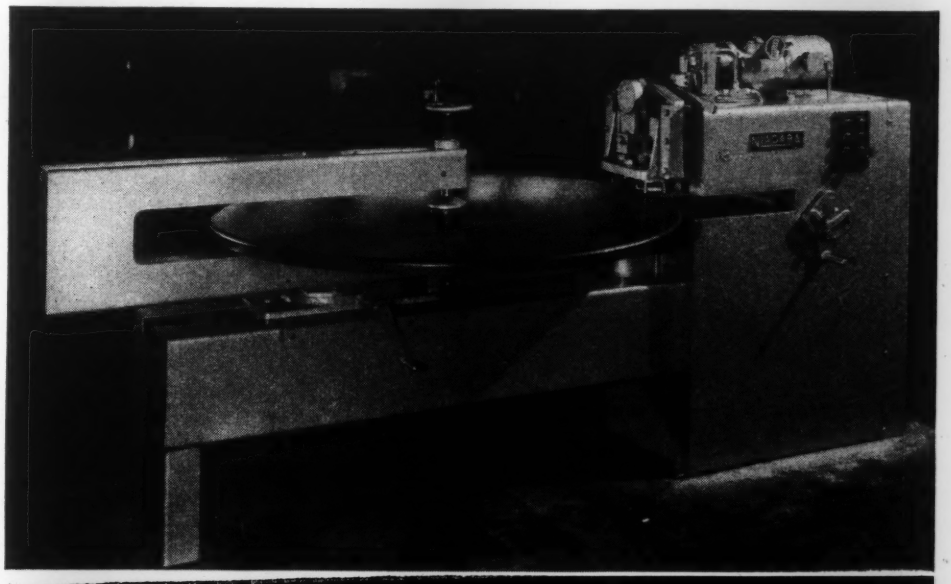
Timken tapered-roller bearings are used in the upper and lower tool spindles, and in the vertical mounted cartridge-type spindle which forms the inside of the flanges. The latter spindle assembly is canted slightly to provide forming roll clearance under the blank. Accordingly, the outside diameter of the forming roll is back-tapered so that the finished flange will be at right angles to the head surface.

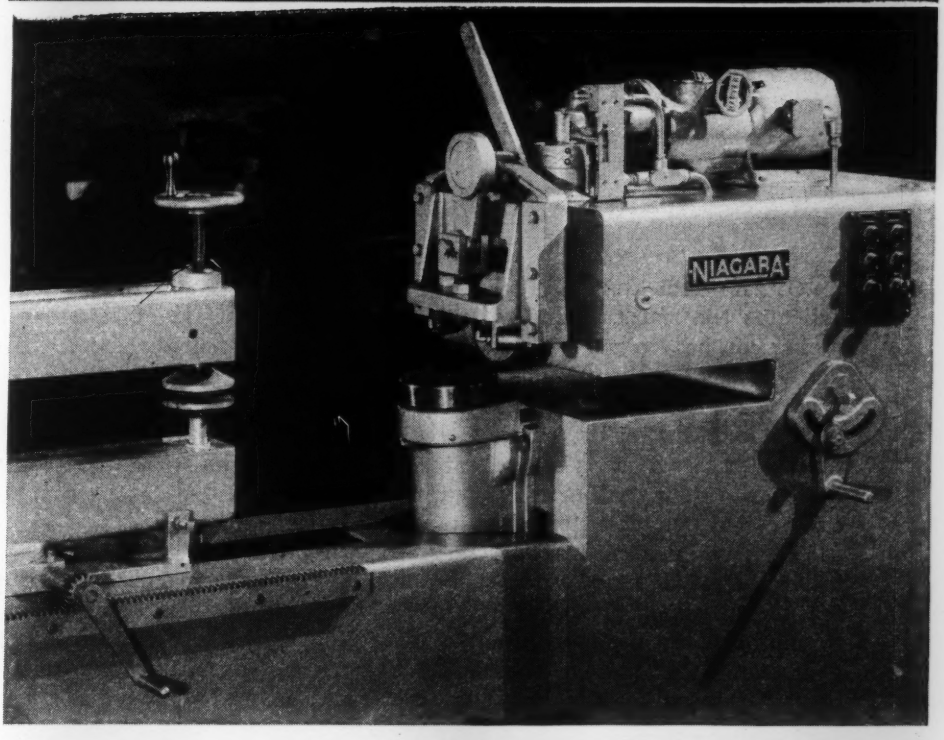
Slide-mounted holddown rolls positioned by a lever-operated eccentric steady the sheet for flanging and maintain contact between the forming roll and sheet. To allow for different gage metals, the upper spindle carrying the spinning roll is adjustable laterally to space the rolls accordingly.

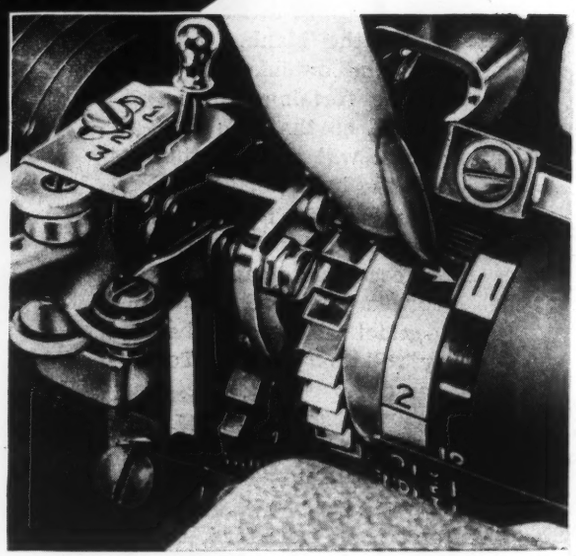
Automatic power feed to the spinning roll eliminates the expenditure of physical effort formerly required for this operation. Variable rates of continuous feed are effected by simple handwheel adjustment of a Master variable-speed transmission and gearhead motor. Micro Switches limit the extreme vertical movement to safeguard against jamming the feed mechanism.

When used for shearing, the forming equipment and holddown rolls are removed, and circular shear blades are mounted directly on the horizontal spindles.

Approximate setup conversion time required is one-half hour. The Niagara Circle Shear and Flanger has a conveniently located pushbutton control station at which an operator can select high speed for flanging or lower speed for shearing and either continuous or jog feed for flanging. The welded frame, bed and arm are finished in gray Hammerloid lacquer.







# Typewriter Gages Page Length

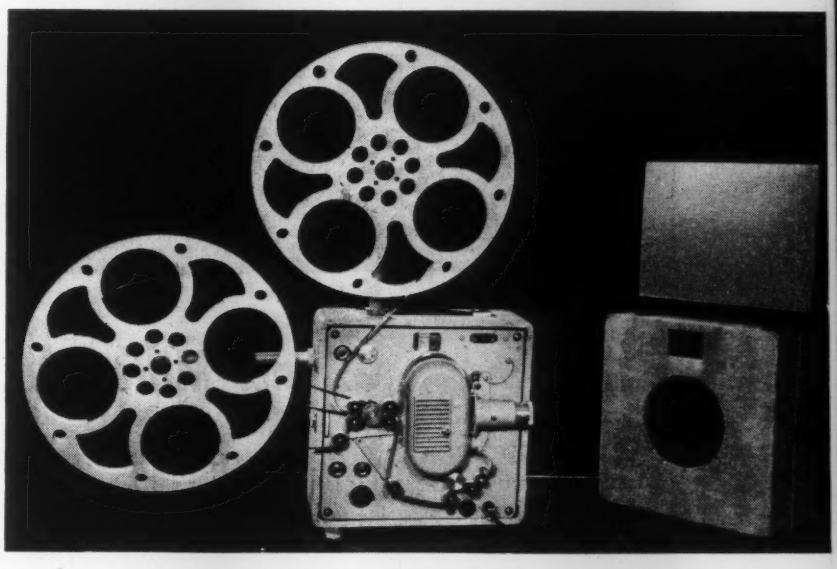
ROTARY indicator ring built into the platen of a new office typewriter, above, indicates the space, in inches, remaining at the bottom of pages so that over-typing can be avoided. When the lines being typed come within 2½ inches from the bottom of a page, numerals on a red signal ring indicate, down to zero, how much space exists to the end of the page.

Readability of the carriage scale is improved by a magnifying window in the center of which is an indicator line. In addition to the three conventional ribbon positions, a fourth is provided to permit typing in the center of a one-color ribbon, thereby increasing its useful life.

A newly designed support segment with extended guide surfaces is said to increase typebar stability, resulting in more accurate spacing. Other mechanical features designed into the new Smith-Corona machine are: half-spacing control to minimize erasures required in correcting errors and fitting in words, interchangeability of platens without the use of tools, centralized margin control, and master clearing key for the tabulator stops.

## Lightweight Projector Arranged Compactly

ABOUT the same size as an average portable typewriter, the complete sound-movie projector shown at right packs into a single carrying case measuring 12 x 12 x 9 inches. Projector, transformer, amplifier, loudspeaker and leads, combined, weigh only 24 lb. Use of light alloys and miniature electrical equipment, with a minimum number of essential components, made this low weight possible. Operated by a single switch, a governor controlled heavy-duty universal motor drives the projector. The shuttle/shutter ratio is 6 to 1, allowing maximum view per frame during each cycle. Sprocket shoes and lay-on idlers have been eliminated from the film circuit which is said to be simplified to a point where the film path can be easily followed even by inexperienced operators. The Sofil "Minor" is produced by Southern Film Services Ltd., England, and uses 16 mm sound or silent film.

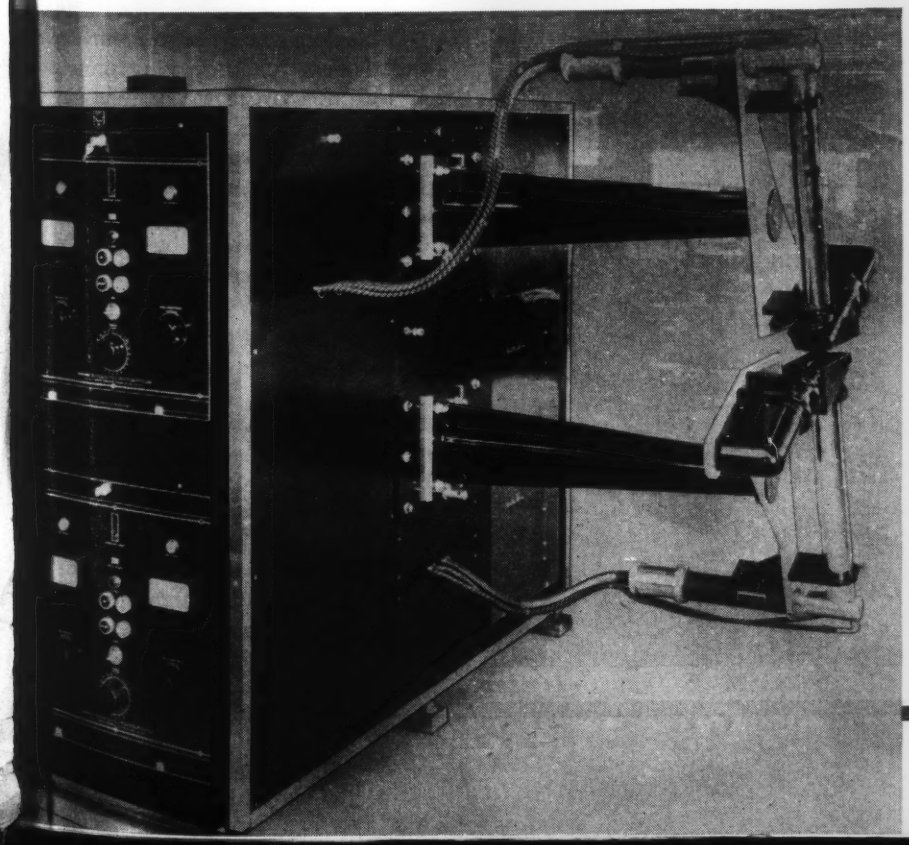


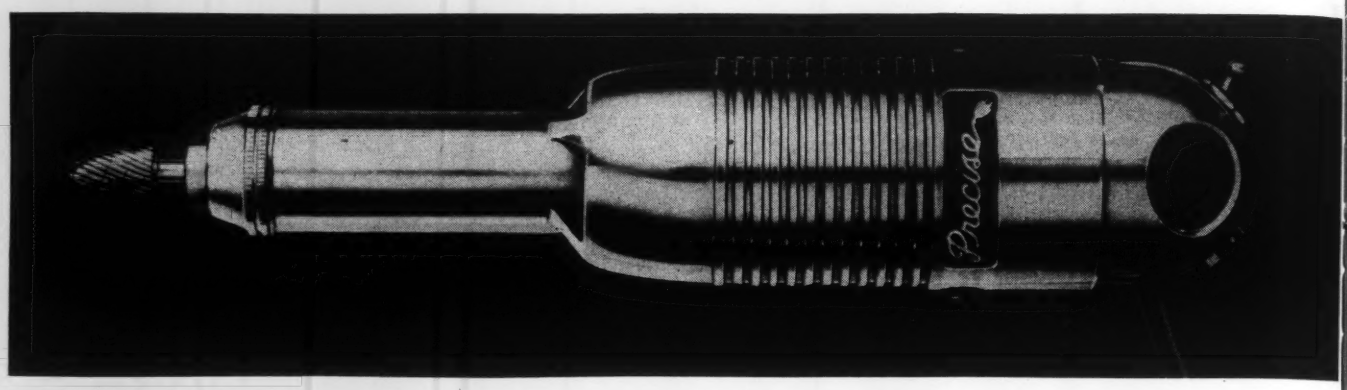
## Instrument Measures Plating By X-ray

AUTOMATIC nondestructive measurement of tin plating thickness is performed quickly and recorded by the instrument shown below. Two detector heads, consisting of X-ray and Geiger counter tubes mounted on backplates, are supported away from the cabinet by ribbed tubular arms to permit gaging plating thickness well inside the edge of the coated sheets.

Controlled voltage X-ray beams are directed simultaneously toward both sides of the sheet at 70-degree angles. The beams penetrate the plating and rays emitted from the steel plate are sensed by the Geiger counters. The intensity of the emergent radiation is an indication of plating thickness. Total Geiger count over a predetermined time interval, usually thirty seconds, is accumulated electrically and print-recorded on tape. An electromechanical counter also registers the count for visual check. Count totals are converted to thickness by using a calibration curve.

The power transformer and X-ray tubes are oil-insulated and watercooled by a system which includes a high flow-rate filter, pressure regulator and gage, and automatic shut-off solenoid to safeguard against abnormal and subnormal coolant flow and pressure. The new thickness gage is made by the research and control Instruments Div. of N. American Phillips Co. Inc.





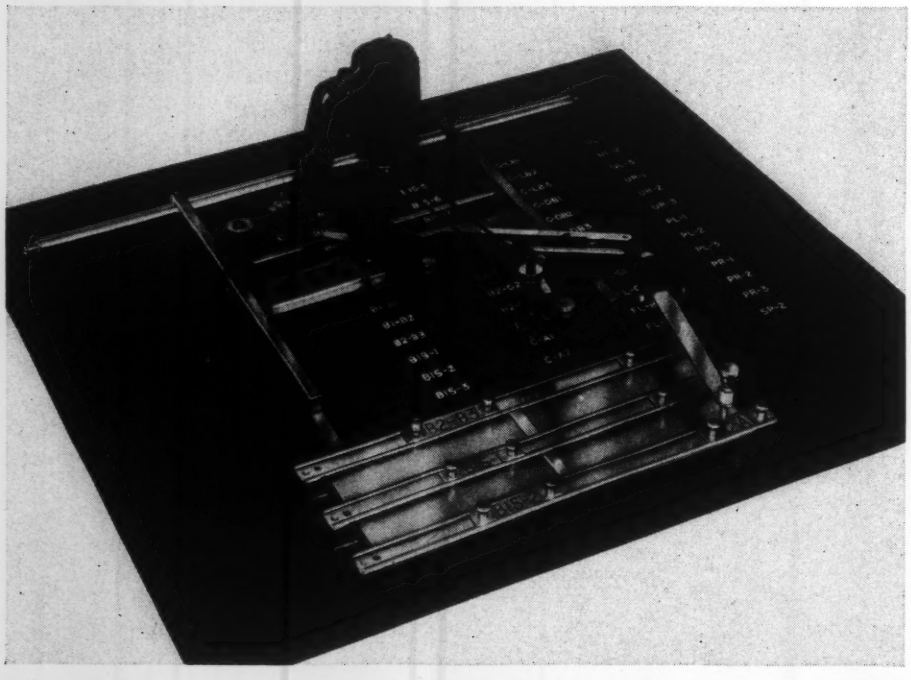

## Grinder-Miller Does Precision Work

MICROPRECISION ball bearing quill enables precision machining and grinding operations to be performed with the Precise Super 40 grinder-miller shown above. Work can be finished to tolerances within one ten-thousandth inch with the unit properly equipped and appropriately mounted in machine tools. The unit can be used also as a portable hand tool for light offhand finishing operations.

Coupled directly to the quill, a ¼-hp controllable-speed universal motor delivers up to 45,000 rpm at high torque under load, cooling air at speeds up to 9000 fpm being induced by a steel impeller. Screened air inlets exclude dirt from the motor, while the skewed-rib outlet vents are said to result in more efficient cooling. The totally insulated cartridge-type motor may be removed as a unit from the one-piece aluminum-alloy housing for cleaning and servicing.

Overload protection is provided by a delayed action fusetron mounted in the endbell which also contains the control switch and spare fusetron chamber. Automatic brush stops indicate when the motor brushes are worn to the replacement stage. Built by Precise Products Co., the $2\frac{7}{16}$-inch diameter by $11\frac{1}{8}$-inch long unit weighs only 3 lb 2 oz. A specially designed flexible shaft may be attached to the chuck for light handwork on small tool and die parts.

## Engraver Attaches to Large Surfaces



TRACER-GUIDED engraver, left, incorporates a detachable chassis which enables it to be used for engraving panels of unlimited size. Whereas previous machines could cover a 25-sq in. maximum area in bench type operations only, the Engravograph, product of New Hermes Inc., can be attached to existing panels or other work surfaces for direct engraving.

Fifteen different sizes of letters and numbers can be reproduced from one assortment of master templates. The copy-holding slides are adjustable on a back plate to permit multiline engraving without moving the chassis for each line. A lightweight flat belt drives the engraving head which has a micrometer spool adjustment for regulating the depth of cut.

# Applying DC Synchros

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*Control Section*
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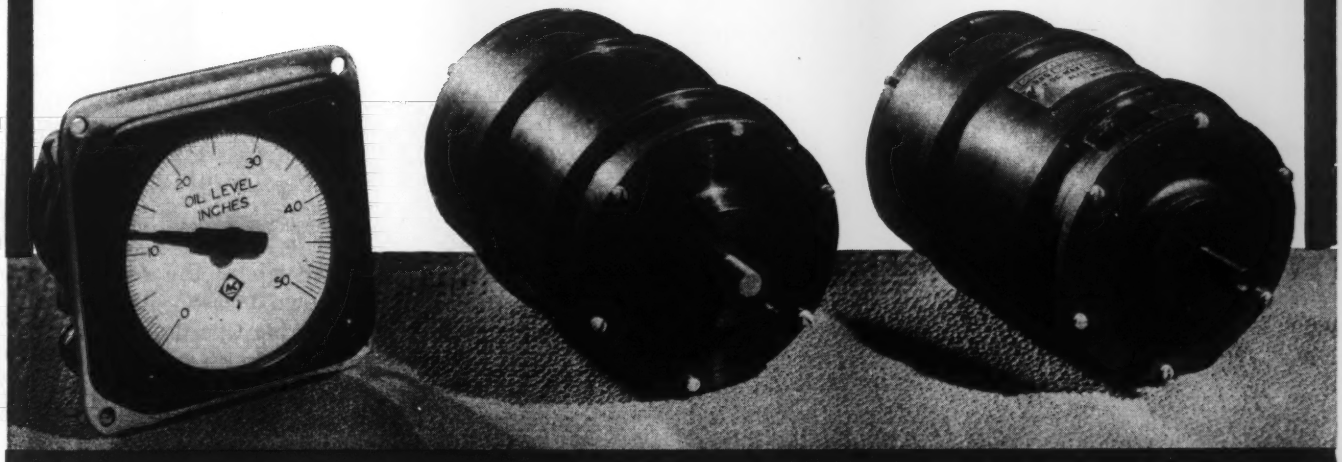



Fig. 1—Typical set of dc synchros: transmitter at right, main receiver and indicating receiver at left.

WIDELY APPLIED for the first time in World War II, dc synchros have become important adjuncts to modern industrial control. They were found especially useful where no ac power was available, and formed the heart of hundreds of marine propulsion controls besides serving many other important functions.

Synchros provide an electrical means for simultaneous transmission of mechanical motion between two or more remote locations. In its simplest form the equipment consists of a device for establishing position, called a *transmitter,* and a device at some remote location, called a *receiver,* which receives the signal from and duplicates the motion of the transmitter.

Inherent characteristics of dc synchros make them useful in many control systems where no other simple device will serve. Since more torque is available from the receiver than is required to rotate the transmitter, the system can be considered as a torque or mechanical power amplifier. The torque required to rotate the transmitter is only that necessary to overcome the friction of bearings, brushes and windage. Neither mechanical load nor electrical power requirements affect the torque required to rotate the transmitter. With certain size combinations, the torque output of the receiver may be as high as 40 times that required to rotate the transmitter. The windings of the receiver or transmitter cannot be burned out due to circulating currents resulting from loading of the receiver. The system will not motorize or hunt and the length of lines between units is not limited by line reactance. A small selenium rectifier may be used to supply the direct current required in locations where only ac power is available.

A typical set of dc synchros is shown in *Fig.* 1. The unit on the right is a synchro transmitter, the center unit is the main receiver and the unit at the left is an indicating receiver. Both receiver units may be operated from the same transmitter.

Basically the dc synchro transmitter is a 360-degree resistance bridge designed for continuous rotation. The resistance element is designed to produce a sinusoidal two-phase current and voltage when connected to a proper two-phase load. *Fig.* 2 illustrates the sinusoidal structure of the transmitter resistance element. Special alloy resistance wire is used for the precise taper of the winding. Accurate steps in the molded core are held to 0.002-inch tolerance in length.

The dc synchro receiver is a motor of special construction. Its stator is special magnetic iron with two-phase, concentric, sinusoidal windings set in quad-

rature. The rotor, for most applications, is a two-pole permanent magnet. For special applications it may be a pure iron slug, may consist of a two-pole wound rotor or, for differential applications, may have a winding similar to the stator.

A schematic representation of the physical structure and electrical connections of the basic dc synchro pair is shown in *Fig.* 3. Four roller brush potential taps are arranged to move concurrently over the transmitter winding. Diametrically opposite brushes are connected to two opposite poles on the receiver and vary sinusoidally the current and magnetic strength of each pair of receiver poles as the potential is changed by movement of the brushes on the transmitter resistance element. The rotor of the receiver aligns itself with the resultant of the receiver stator poles. Thus the operation of the transmitter may be compared to that of a low-frequency, two-phase synchronous generator and the receiver to that of a two-phase synchronous motor.

Proper application of synchros requires a thorough understanding of their basic characteristics. The following explanation of dc synchro characteristics will serve as a guide in considering their use.

When the rotor of a receiver is perfectly aligned with the resultant magnetic axis of the stator, no torque is exerted by the receiver rotor. However, any attempt to move the rotor mechanically from this position in either direction would be resisted by an increasing amount of torque as the angle of movement was increased. This condition would hold until the pull-out point of the rotor was reached. At this point, usually 90 degrees from the initial position, the torque is reduced with additional rotor motion until the rotor reaches 180 degrees from the initial position, where the torque exerted by the receiver rotor will again be zero. A typical static torque curve is shown in *Fig.* 4.

In applications where the transmitter and receiver are in continuous rotation, a torque characteristic other than the static torque characteristic must be considered—the speed-torque characteristic. At standstill the maximum torque available in the receiver is found at the pull-out point. When the receiver is rotating, a certain amount of this maximum static torque is used in overcoming such losses as windage and friction, but the greatest torque reduction is caused by the back emf generated in the receiver windings. The maximum available torque output of any receiver that is rotating is the difference between the maximum static pull-out torque and the receiver's rotating losses. It is, therefore, only logical that a speed will be reached where the receiver will be able to supply only its own losses. Any attempt to operate the receiver at higher speeds will cause it to pull out of synchronism with its transmitter. A typical speed-torque characteristic is shown in *Fig.* 5. The exact shape of this curve may be varied in the design by controlling the receiver's air-gap and rotor shape.

Four sizes of dc synchro receivers are listed in TABLE 1, showing their static and speed torque characteristics. Consideration of a number of synchro applications will show the design engineer how to apply such units to similar or even more complicated equipment.

Fig. 2—Above—Core and winding of a synchro transmitter resistance element

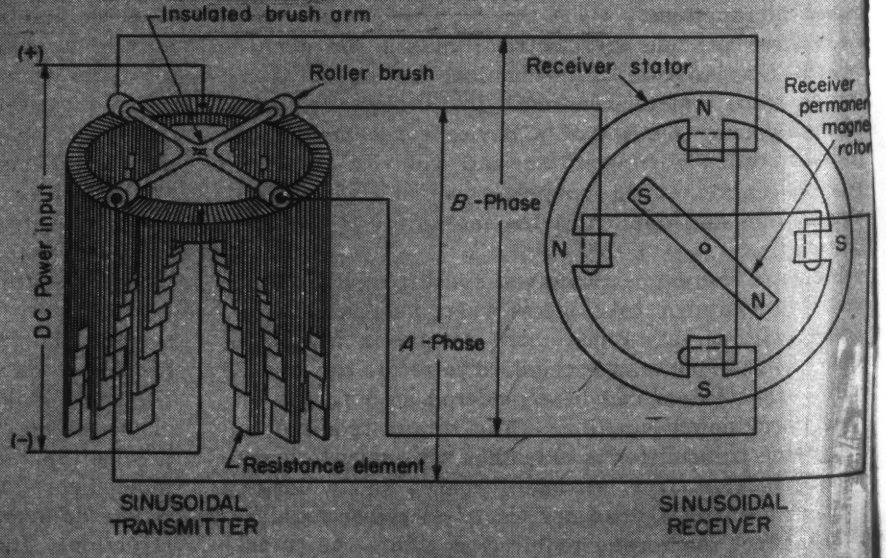



Fig. 3—Right — Schematic diagram showing physical structure and electrical connections of a basic dc synchro pair

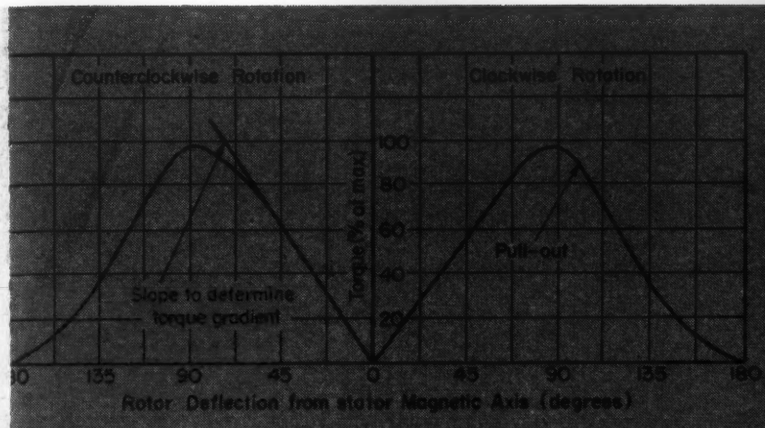



Fig. 4—Above—Typical static torque versus rotor deflection for a dc synchro receiver

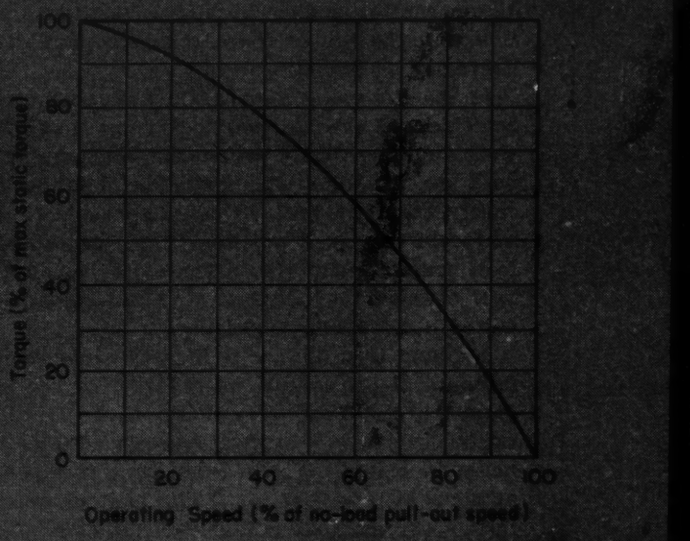
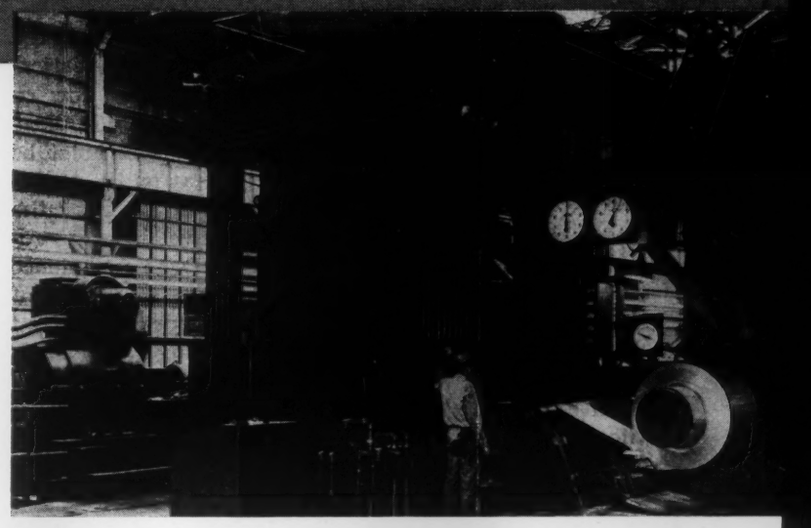



Fig. 5—Above, right—Typical speed-torque characteristic of a dc synchro receiver

Fig. 6—Right—Operator's side of a four-high temper pass mill in which thickness of the rolled sheet is indicated by dc synchro system



Applications of synchros may vary from equipment used in removing the skins from skinless wieners to a governing device in a complex computer. The most common use is the remote indication of some mechanical motion, such as water level or the thickness of rolled sheet steel, *Fig.* 6. Screw down indicators using dual pointers, gears and a zero to one-inch scale can be designed for accuracies better than 0.001-inch.

Dc synchros are used for torque applications where it is desired to rotate such devices as rheostats or valves through fixed angles of travel. They are also used in closed cycle systems to remotely control the travel of motor-driven equipment, such as large valves, weirs and gates.

In addition to proper consideration of the synchro characteristics, care must be exercised in most applications with the mechanical connections to the transmitter and with the receiver loading. Careful co-ordination of electrical and mechanical characteristics is alway important.

A typical indicator application which combines the use of synchros with other electromechanical devices is shown in *Fig.* 7. In a hot reduction mill, it is often required to replace the reduction rolls. The driven rolls are coupled to the driving source by means of a tongue-and-groove coupling, the tongue portion being located on the roll. When the rolls are being replaced, it is necessary to align the two portions of the coupling. The rolls are placed near the drive motor with the tongue of the coupling always in the same position. The operator must then align the motor portion for insertion of the roll. However, the drive motor controls and the operator are located in a pulpit a considerable distance from the rolls. In the past the use of hand signals between a man located at the drive motor and the operator in the pulpit resulted in errors and lost time.

A synchro transmitter (driven by a magnetic clutch connected to the drive motor) and an indicator (located in the pulpit and electrically connected to the transmitter) now show the position of the motor portion of the coupling. Thus with the indicator at zero position, the two portions of the coupling are in proper alignment for insertion of the rolls. The magnetic clutch connects the transmitter to the drive

**TABLE 1—Design Characteristics of DC Synchro Receivers**

| Characteristic | Receiver Number | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Rating, watts | 5 | 40 | 50 | 200 |
| Torque Gradient per Degree Rotor Deflection, lb-in. | 0.006 | 0.043 | 0.40 | 1.4 |
| Maximum Static Pullout Torque, lb-in. | 0.312 | 1.985 | 20 | 120 |
| Torque at 50 rpm, lb-in. | .... | 1.875 | 10 | 90 |
| Torque at 100 rpm, lb-in. | .... | 1.750 | 5.5 | 27 |
| Torque, lb-in. | .... | 0.625 | 2 | 8 |
| at Speed, rpm | .... | 750 | 160 | 100 |
| Primary Usage | Indicating | Indicating & Torque | Indicating & Torque | Torque |
| Accuracy* for 360° Rotation, % | ±1 | ±½ | ±1 | ... |
| Weight of Receiver, lb | 2 | 8 | 45 | 75 |

* Combined accuracy of a receiver and transmitter.

motor only during the roll-changing operation and disconnects it during high-speed mill operation. In this way the life of the transmitter and the receiver is greatly increased.

In the foregoing application the speed-torque characteristic of the receiver was not a factor since the clutch engages only when the mill motor is being used for inching. The magnetic clutch is of special construction in that it can only engage the drive motor in one fixed position. The indicator, mounted in a control cubicle with the motor inching controls, now enables the operator to align the roll with the motor quickly and positively.

A liquid level indicator illustrates well some of the mechanical considerations required in the proper use of synchros. In this application the transmitter rotation is obtained by float movement, this movement being indicated or recorded with a receiver indicator at some remote location. The float drives the transmitter through a chain-driven sprocket and gearing. The usual electrical connections between the transmitter and receiver are required.

Since the float movement is a direct measure of the liquid level, the float must move only in a vertical plane. Any horizontal motion due to liquid flow or other causes will result in inaccurate indication. Furthermore, any turbulence of the liquid level must be damped out, since it will accelerate wear on the transmitter and receiver, making it difficult to read the indicator accurately. If the liquid level is being recorded on a chart type recorder and the turbulence is not damped out, the recorded data might be of little or no value. Turbulence and horizontal float movement may be eliminated by placing the float in a pipelike float well with a liquid entrance at the bottom and a diameter slightly larger than that of the float. The size of this entrance is adjusted to minimize the effect of the turbulence.

## Accurate Gearing Is Required

Indication of liquid levels which vary as much as fifty feet is not uncommon. With wide changes in level, gearing between the chain sprocket and the transmitter is required. Proper design of the gear train is an important factor in the successful installation of such a system. High spots or other uneven surfaces on the gears will result in inaccurate or erratic operation. The diametral pitch of the gears selected should be 64 dp or smaller in most applications. Since gear ratios of 1000:1 are not uncommon, a larger size gear tooth would result in a gear train too large in physical dimensions. Precision gears are mandatory. Any backlash in a gear train results in an indication error proportional to the angular movement lost in the gear train.

With perfect mechanical connection to the transmitter and proper electrical connections between the transmitter and receiver, a maximum error of the magnitude of 1 per cent of full indicator scale is not uncommon. This error may be reduced by gearing between the receiver and the indicator pointer, the error being reduced almost in direct proportion to the gear ratio. The gear train must be designed with

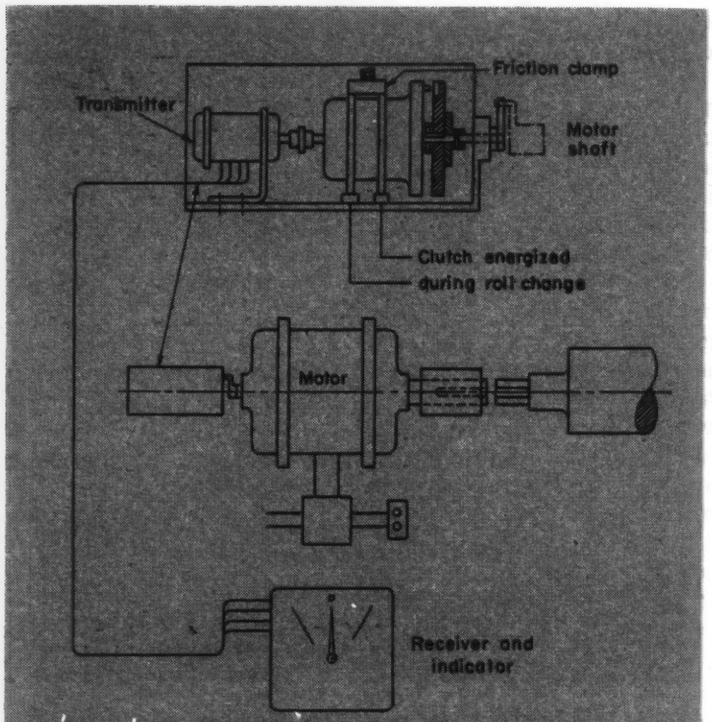



Fig. 7—Dc synchro system for remote indication of mill roll rotational position. System is used to align tongue-and-groove coupling when replacing rolls

practically no friction or backlash. Referring to *Fig.* 4, the transmitter must rotate through a fixed angle before the torque of the receiver is sufficient to overcome the friction of the gears and to cause actual motion.

If the transmitter then rotates in the opposite direction, it must travel through an angle equal to twice the original angle before the receiver will again start to rotate. This dead-band is the electrical equivalent to the backlash of a gear train and is additive to any gear backlash.

Schematic representation of a control for a rock grinding mill is illustrated in *Fig.* 8. This mill must process a great variety of materials, hence a highly flexible control system is required. The speed of the master motor is varied over a range of four to one, this variation being accomplished by standard control methods using armature and field control. The slave motor operates at a fixed speed ratio with the master motor. This ratio can vary from 1:1 to 4:1 above or below the speed of the master. The load on the rolls varies considerably due to the nature of the material being processed. For example, one part of a load of mineral ore could be made up of hard rock and another of relatively soft materials.

The mechanical differential portion of this control has been successfully applied to machine tools, keeping two independent feed motors within a few revolutions of each other throughout long machining operations. Integrators similar to the ball and disk type have been used in indicating functions and can be built with accuracies up to one part in several thousands. The system therefore combines a set of

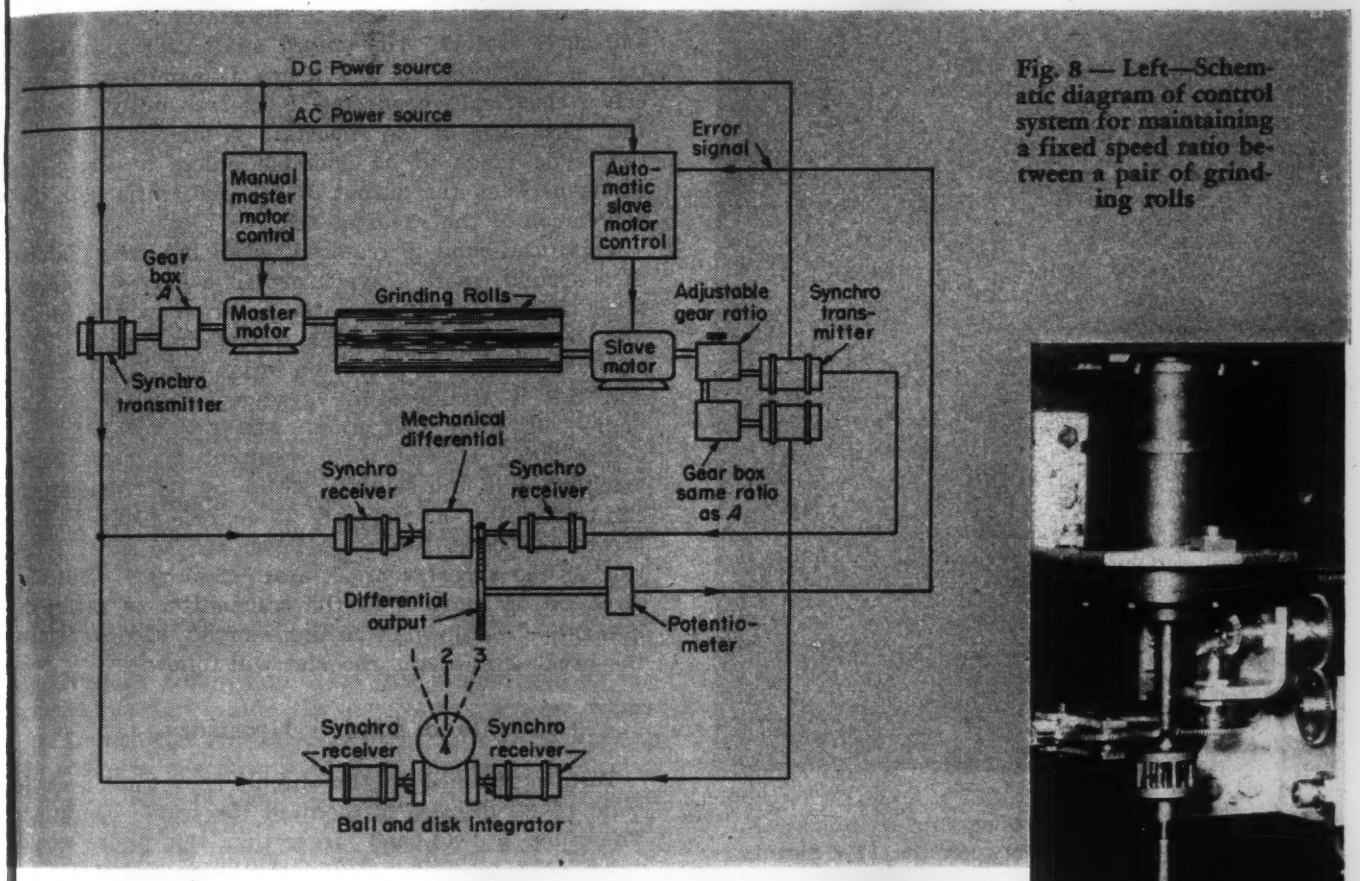



**Fig. 8 — Left—Schematic diagram of control system for maintaining a fixed speed ratio between a pair of grinding rolls**

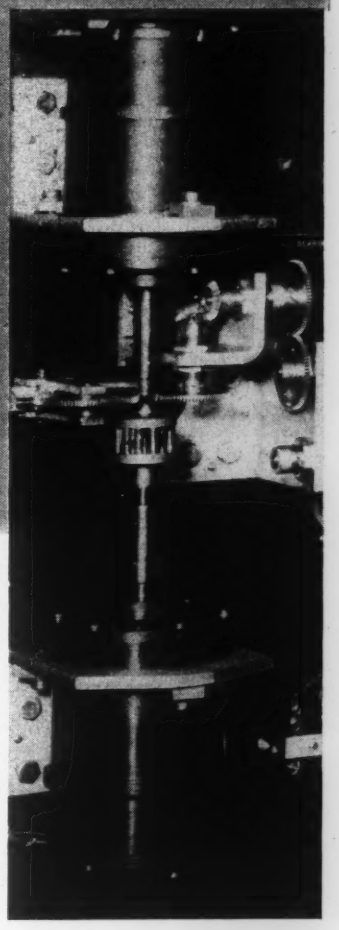


Fig. 9—Right—Mechanical differential driven by two dc synchros, similar to unit incorporated in system of *Fig. 8*

components whose performance and reliability have been well proved in actual practice.

Assuming that the adjustable gear ratio between the slave motor and its transmitter is set to the same ratio as the fixed gear unit between the master motor and its transmitter, and that the two motors are rotating at identical speeds, the two transmitters and their respective receivers will rotate at identical speeds. The connections to the two receivers are arranged so that the two receivers are rotating in opposite directions. With the output shafts of these two receivers connected to the input shafts of the mechanical differential, the output of the mechanical differential would be zero.

## Responds to Relative Speeds

Two dc synchro receivers driving a mechanical differential are shown in *Fig.* 9. When the speed of one motor or the other varies as little as one revolution in any period of time, the output shaft of the mechanical differential starts to rotate. In so doing it rotates the brush arm of the potentiometer in the direction that will result in correcting the speed of the slave motor. Only 2 lb-in. torque is required to rotate this rheostat. The correcting signal of the rheostat is interpreted by the automatic electronic slave motor control which holds the speed relation of the two motors. Changing the gear ratio between the slave motor and its differential is only a means of "fooling" the mechanical differential and its receivers. The only thing this control system recognizes is the relative speeds of the synchro transmitters and receivers, so by varying the gear ratios between the slave motor and its transmitter, the control can be made to regulate at any desired speed ratio.

With the ball and disk integrator, the two synchro receivers driving the two disks of the integrator rotate in the same direction and at identical speeds when the motors are running at equal speeds. Under this condition the axis of rotation of the ball is a line parallel to the receiver shafts. A pointer perpendicular to the axis of rotation would be in position 2, *Fig.* 8. If the master motor rotates at some speed faster than the slave unit, this pointer would be in position 3. Likewise, with the slave motor rotating the same amount faster than the master, the pointer would be in position 1. Thus a shoe, upon which the ball is rotating would align itself with the axis of rotation of the ball. A pointer connected to this shoe and a dial properly calibrated would

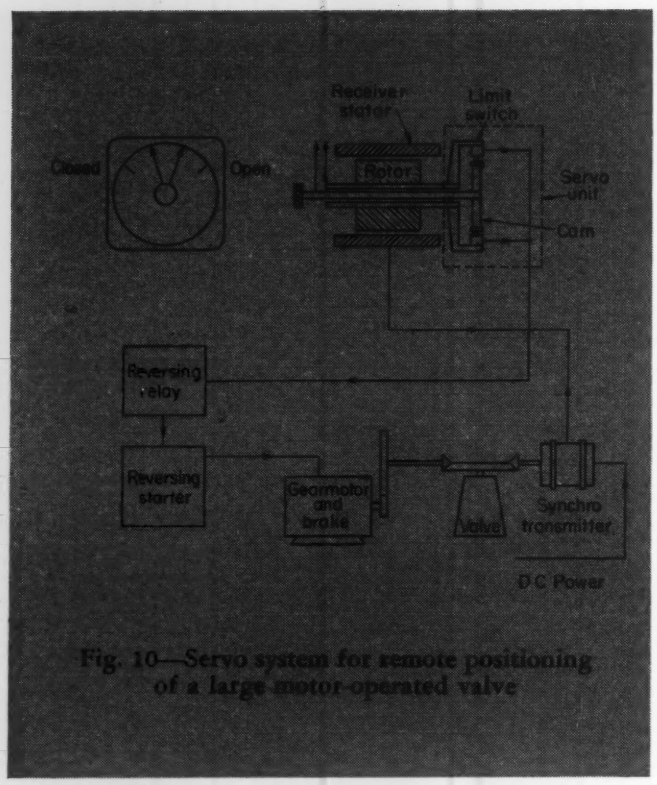



Fig. 10—Servo system for remote positioning of a large motor-operated valve

indicate the speed ratio between the two motors.

The designer of this type of system must consider the speed-torque characteristics of the synchro receiver. Here the application of the receiver to the mechanical differential limits the maximum receiver and transmitter speed because the differential requires more output torque from its receivers than does the integrator.

## Uniform Loading Obviates Hunting

Mechanical design and the accuracy of machining of the integrator and differential are of equal importance for successful system performance. If there were gear backlash or nonuniform friction in the differential or integrator, the system would tend to oscillate because a varying torque would be required to rotate the units. A rotor of a synchro receiver, like the rotor of a synchronous motor, reduces its angular velocity for an instant upon the sudden application of load, and then continues to rotate at synchronous speed but at an angle of lag behind its transmitter. Likewise, upon the removal of this load, the rotor accelerates momentarily until it has reached its initial position with relation to the transmitter. It is, therefore, of prime importance that the loads on the receiver be constant throughout its angular travel to avoid an oscillating condition within a revolution of the receiver.

A less sensitive control, performing similar functions and using less expensive parts, can be substituted in systems where regulation requirements are less stringent. Here the control scheme uses a standard rheostat directly connected in the shunt field of the slave motor. The differential input shafts are connected through gearing to the shafts of the master and slave motors. The output shaft of the differential is connected to a synchro transmitter. A receiver electrically connected to the transmitter rotates the brush arm of the rheostat. A simple system of this type tends to be unstable unless a dead-band exists between the output of the differential and the movement of the rheostat arm.

This dead-band is required as an inherent feature of a system where a synchroreceiver drives a torque load. In this application the rotation of the brush arm of a rheostat requires a 10-lb-in. torque. The receiver selected to drive the brush arm of the rheostat has a static torque gradient of 0.4-lb-in. per degree of rotor deflection. Starting with the receiver rotor aligned with resultant magnetic poles established in the receiver stator by its transmitter, the transmitter must rotate 25 degrees ($10/0.4 = 25$) before sufficient torque is developed to start rotation of the rheostat brush arm. If at this point the direction of rotation of the transmitter is reversed, it must move through an angle of 50 degrees before the brush arm of the rheostat will follow.

## Dead Band Is Necessary

Tests performed on this circuit show that a dead-band of 20 degrees is required for stable operation. Therefore, a dead-band larger than this figure would serve only to reduce the control's sensitivity. The 50-degree dead-band may be reduced to 20 degrees by gearing between the differential and the transmitter, as well as between the receiver and the rheostat. This system is able to maintain the speed ratio between the two motors within relatively coarse limits. With minor revisions to the mechanical circuit driving the transmitter, this system could be made to regulate the speed of the motors in response to any similar mechanical function.

Many torque loads are beyond the capacity of standard synchros. When it is desired to position a load of this type by remote control, a system similar to that shown in *Fig.* 10 may be used. The system shown in this illustration is being used to remotely position a large motor-operated valve located several miles from its control station.

An operator desiring to change the valve opening turns the knob located at the front of this indicator so that the pointer connected to it points to the desired valve position. In turning the knob, the operator turns a shaft and a cam connected to the shaft, *Fig.* 11. The cam, according to its direction of rotation, operates one of the two limit switches in mechanical contact with the cam. Closing this limit switch (*CLS* in *Fig.* 11) then energizes one of the reversing relays, permitting the closing of one of the reversing motor starters. This in turn connects power to the valve drive motor, causing it to rotate in the desired direction. A dc synchro transmitter geared to the valve rotates when the valve rotates, the transmitter being electrically connected to the follow-up receiver.

Since the torque on the receiver is small, the receiver rotor follows the rotation of the transmitter

with no appreciable angle of lag. A pointer on the receiver shaft indicates the exact valve position. The limit switches on the other end of the receiver shaft are operated by the cam. The valve continues turning until the limit switches driven by the receiver reach the point where the closed switch will be opened by the cam that started the sequence and thus de-energize the valve drive motor. At this point both indicator pointers agree.

Accuracy of this system is largely dependent upon the amount of overshoot of the drive motor when its power is removed. Any movement, after power removal, means that the opposite limit switch (*OLS* in *Fig.* 11) must be moved from the original far enough so it will not be operated by the overrun of the motor. If this switch were to be closed it would start the drive motor rotating in the opposite direction. The motor would then oscillate back and forth and would continue to do so until power is removed from the drive motor or control.

## Transmitter Makes Less than One Revolution

Effect of power failure on this system was an important design factor. In any control scheme where the transmitter and receiver make several revolutions to complete a sequence of operation, there is always the possibility of the units falling out of synchronism during power failure, when the transmitter might rotate with its power removed. Since the valve, in this application, could be operated without the transmitter and receiver being energized this system is arranged so the transmitter makes less than one revolution for the complete travel of the valve. Then any time power is applied, the receiver aligns itself with the transmitter, its position being in a true representation of the valve position. In actual practice the rotation of the transmitter and receiver is limited to 170 degrees by the design of the cam which operates the limit switches.

In many applications, for reasons of accuracy, the transmitter must make several complete revolutions to cover a complete range of operation, yet after power failure the system must return to synchronism when the power is restored. When these requirements are present a coarse-fine type of system is usually employed. A system of this type utilizes two separate sets of synchro transmitters and receivers. For example, it may be desired to measure a liquid level, that will vary forty feet, within an accuracy of 0.1-foot. In this case the float, chain and sprocket would be selected so that the sprocket would make one complete revolution for each one-foot change in the liquid level.

One of the transmitters, called the *fine* transmitter, would be connected to the sprocket without gearing. The receiver indicator, electrically connected to the transmitter, would also make one complete revolution for each one foot change in liquid level. Also connected to the same sprocket, through a gear ratio of 40:1, would be a second transmitter called the *coarse* unit. The receiver electrically connected to this transmitter would make one complete revolution for a 40-foot change in liquid level. When power fails in this system, it is reasonable to assume that the float will move several feet before power is restored. Upon the resumption of power both the coarse and the fine receivers will align themselves with their respective transmitters. Since the coarse synchro set makes no more than one revolution at any time, its receiver must indicate the actual liquid level to the nearest foot. The fine receiver, making one revolution per foot, indicates to the nearest 0.1-foot.

A remote torque-positioning application utilizing a coarse-fine system is illustrated in *Fig.* 12. In this application it is desired to maintain the height of four gates at a fixed distance above the liquid level in which the float is located. Like the coarse-fine indicator system previously described, the liquid level in this application could vary forty feet. The float, chain and sprocket arrangement is selected so the sprocket would make 170 degrees of rotation for each change of one foot in liquid level. The gear ratio between the sprocket and the coarse transmitter is chosen so the transmitter rotates 170 degrees for a 40-foot change in liquid level. Electrically connected to each of the transmitters are four receivers, one controlling each gate. Each receiver exactly follows the motion of its transmitter. Connected to each receiver output shaft is a cam, and connected to each gate drive motor, through suitable gearing, are two

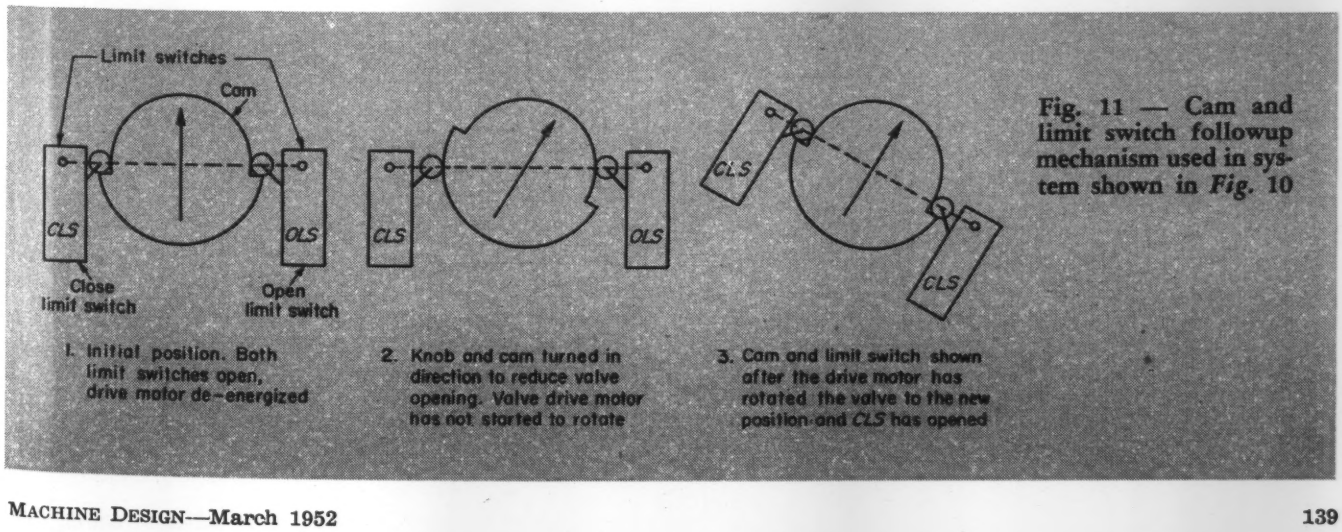



**Fig. 11 — Cam and limit switch followup mechanism used in system shown in *Fig.* 10**

limit switches—one intended to operate the drive motor counterclockwise and the other clockwise. The arrangement of the cams and limit switches is like that illustrated in *Fig.* 11.

Gear ratio between the drive motor and the set of coarse limit switches is such that the limit switches will rotate through 170 degrees for forty feet of gate travel. The gear ratio between the fine limit switches and the drive motor is such that they will rotate through 170 degrees for each foot of gate travel. With these conditions present and with the float and gate moving up or down in absolute synchronism, all sets of cam and limit switches will remain in the position relative to each other, shown by 1 or 3 in *Fig.* 11—that is, they remain in synchronism. In operation the gate is moved by action of this automatic control. The limit switches operate the reversing motor starters for the gate drive motor as shown by 2 in *Fig.* 11. The gate drive motor is de-energized when the cams and limit switches are in the position shown by 3 in *Fig.* 11.

## How Coarse-Fine System Functions

To demonstrate a typical control sequence, using the operation of one of the gates as an example, it may be assumed that a power failure has occurred, and that before the power is restored the liquid level activating the float dropped 20.6 feet. In all probability, one limit switch of the coarse servo unit as well as one limit switch of the fine servo unit will be closed. Since the coarse servo unit has moved less than 170 degrees during the power interruption, the limit switch in this unit which is closed will attempt to rotate the gate drive motor in the correct direction in order to restore the gate and float to their required relationship. However, since the fine transmitter has made several rotations during the period of power interruption, it is possible that the limit switch which is closed in this unit may be the one that would drive the gate drive motor in the wrong direction.

To prevent this from occurring a relay circuit is employed, so that whenever a limit switch in the coarse system closes, its signal takes precedence, superseding the signal of the limit switch of the fine servo unit. The limit switch of the coarse unit maintains command of the direction of rotation of the gate drive motor until the gate and the float are within a fraction of a foot of the required difference between the two units. At this time, it passes command to the limit switch of the fine system servo. With the float and gate so close to the desired differential between them, the limit switch closed in the fine servo will then continue to drive the gate drive motor in the correct direction until the differential is within the nearest 0.1-foot of the required difference. The limit switch in the fine unit will then open, stopping the rotation of the gate drive motor and leaving the gate in the correct position.

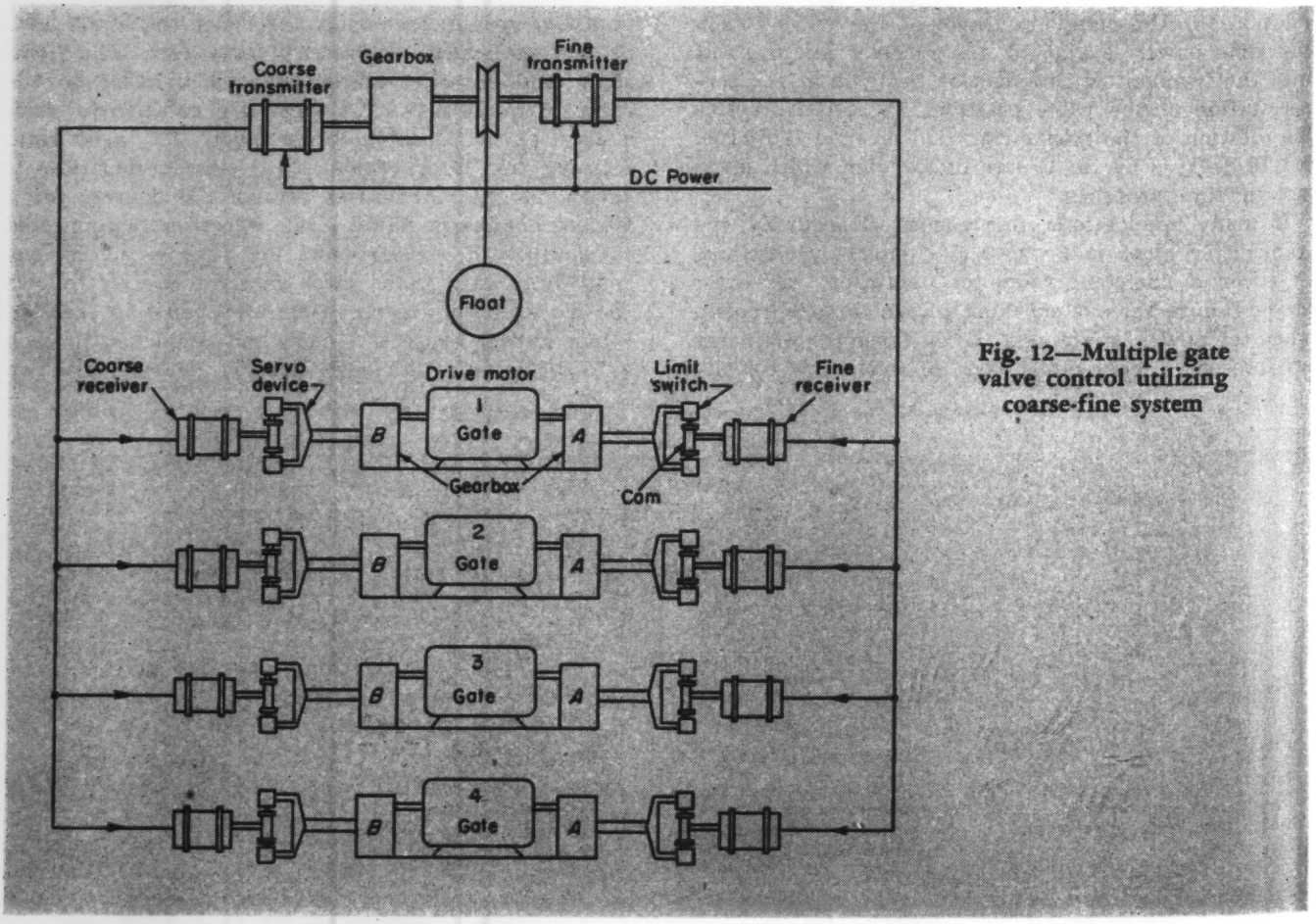
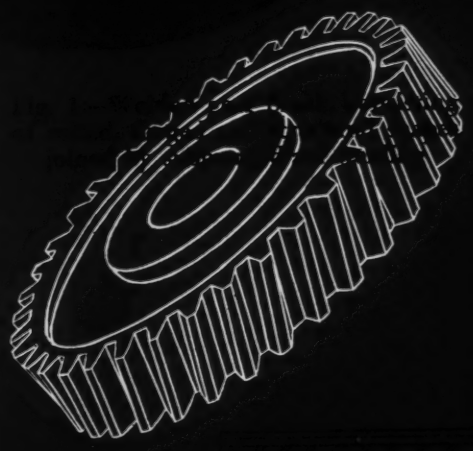



**Fig. 12—Multiple gate valve control utilizing coarse-fine system**

# WELDED GEAR BLANKS



WELDED gear blanks offer flexibility which in many cases cannot be attained with one-piece gear forgings. Low-production gearing, or gears beyond the size capacity of available forging equipment, can be produced easily. Only simple forged-steel and structural shapes are involved, eliminating the expensive forging dies needed to produce more complicated one-piece forged blanks. In addition, the blank can be designed to secure maximum rigidity with minimum weight.

A typical welded gear blank, *Fig.* 1, consists of a medium-carbon (SAE 1045) steel rim, structural-steel plate webs and a low-carbon steel hub, joined by submerged-arc welding. Rim material can be varied within the limits of weldability, and can be formed by roll forging to produce a seamless rim, or by the roll and flash-weld process. The two web plates are joined by stiffeners, *Fig.* 2, to increase stiffness of the gear blank in the axial direction. In single-web gears, these stiffeners are triangular in shape, *Fig.* 3.

Design of welded joints depends on size of the gear, thickness of the web plates, and weldability of the rim material. If welding is to be performed by the submerged-arc process, space between the members being welded must be closed with a back-up member to prevent blowthrough and loss of deposited metal. This back-up can be provided by step machining both the rim and the hub as shown in *Figs.* 2 and 3. Type of edge preparation on web members depends on thickness of the web members and depth of penetration of the weld. If the web plate is thin, complete penetration can be obtained without special edge preparation. As web thickness increases, percentage of

penetration decreases, and it may be necessary to bevel the edge of the web plate to obtain sufficient weld penetration.

Welding procedure depends on degree of weldability of the rim material and diameter of the gear blank. If the rim material has low weldability, it may be necessary to preheat the assembly before welding to prevent cracking under the weld bead, and in some cases postheat will be required. After the blank is welded it must be stress relieved or heat treated to remove welding stresses. If these stresses are not removed, the blank will distort after it is machined, and this distortion adversely affects tooth action.

## Preheating Not Required

Preheating or postheating is not necessary with the gear blank shown in *Fig.* 1, since the welding process itself develops the preheat necessary to prevent under-bead cracking. Two passes around the rim accomplish this purpose. The first preheats the rim to approximately 200 F, and the second increases this temperature to 600 F. Experience with this procedure indicates that it is satisfactory for rims made of SAE 1054 steel up to 54 inches in diameter. To obtain satisfactory results, high currents must be used, and the second pass must be made immediately after the first.

To assure proper load distribution across the tooth face and proper tooth action, gear blanks must be designed to resist distortion due to heat-treating stresses, machining stresses and service loads. If the blank distorts during the tooth generating process, the resultant tooth will be inaccurate. If distortion occurs in service, load distribution across the gear face will be unbalanced, and the load capacity of the gear set will be reduced.

Heat treating usually creates residual circumferential tensile stresses which distort the gear rim when metal is removed unless the gear blank is designed to resist them. Amount of distortion depends on face width of the gear and metal thickness under the gear teeth, with magnitude of the distortion decreasing as metal thickness increases.

## Factors Limiting Face Width

These stresses cause distortions in single-web gear rims, *Fig.* 4, which crown the rim, thus limiting the face width of this type of gear. Since basic construction of the gear blank depends on face width,

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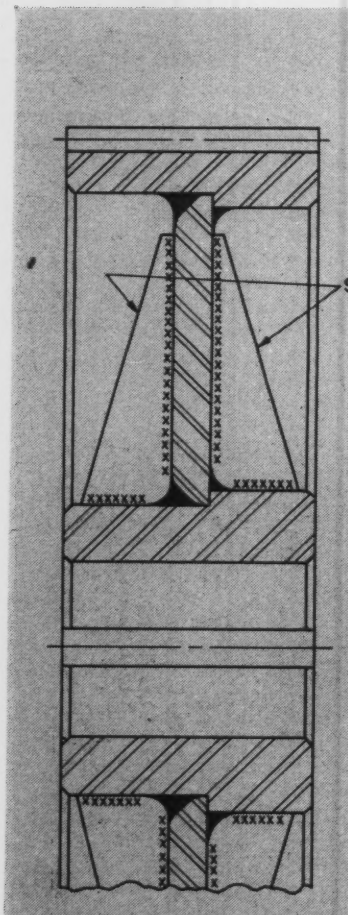



Fig. 3—Triangular stiffeners used in single-web gears. Rim and hub are step-machined to back up the web weld

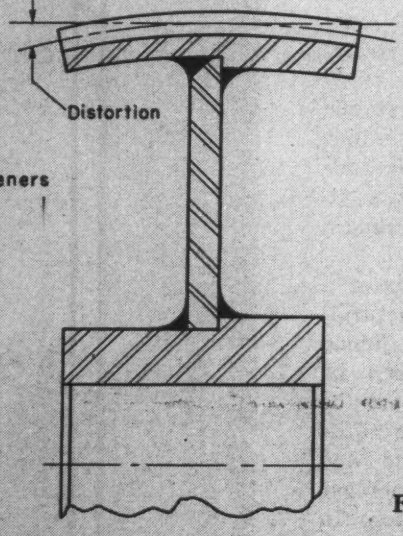



Fig. 4—Distortion of the gear rim in single-web gears, caused by residual heat-treating stresses

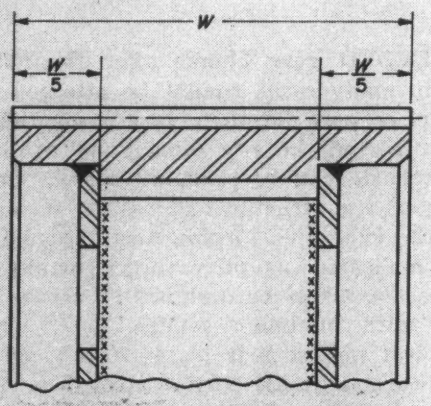
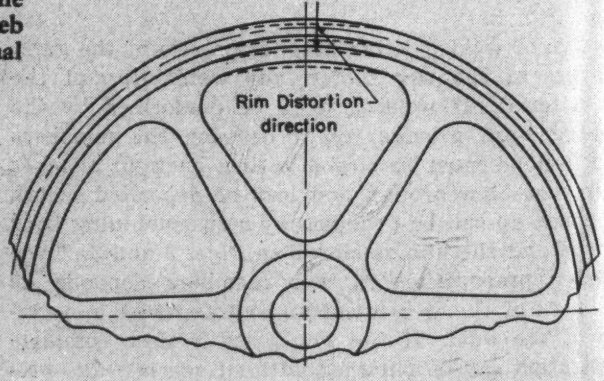



Fig. 5—Above—Optimum position of web plates to resist rim distortion

Fig. 6—Below—Rim distortion in web plates with large access holes



DESIGN

# Redesign for Die Casting

***. . . reduces machining and inspection costs on precision parts***

By Fenton Miller
*Chief Engineer*

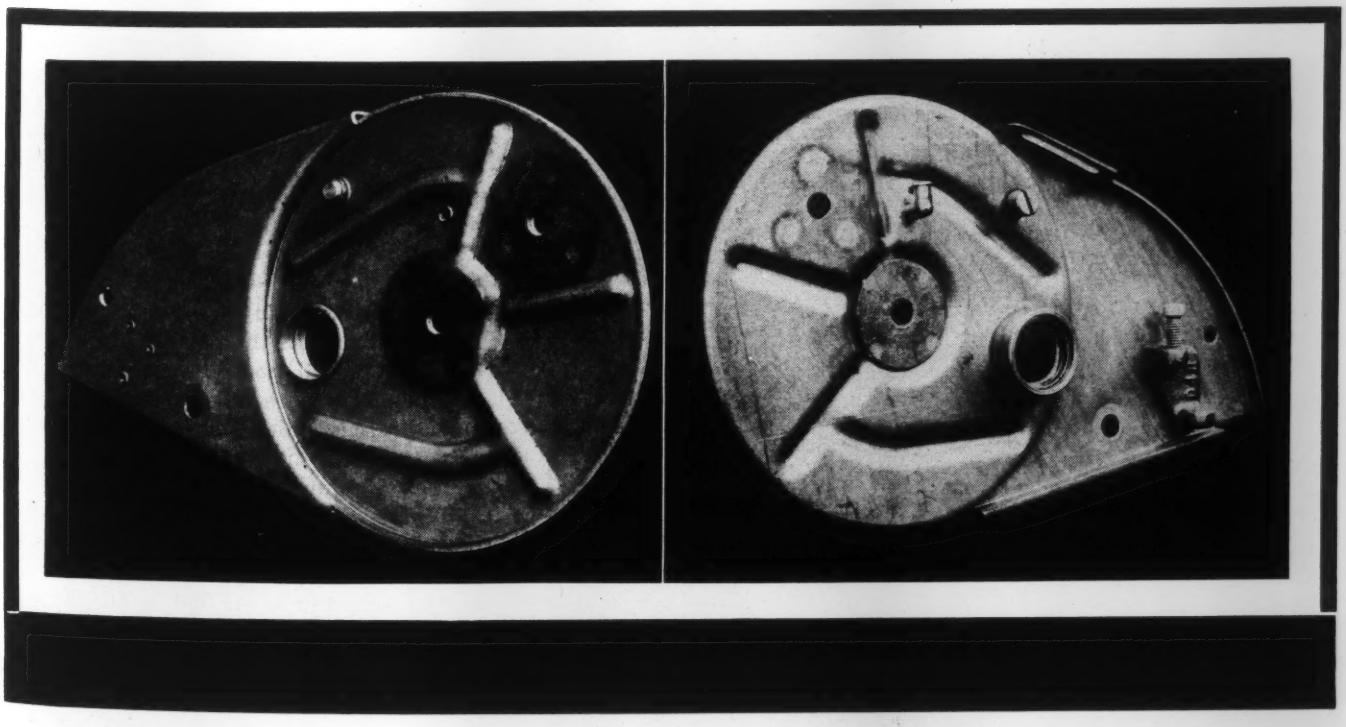
and

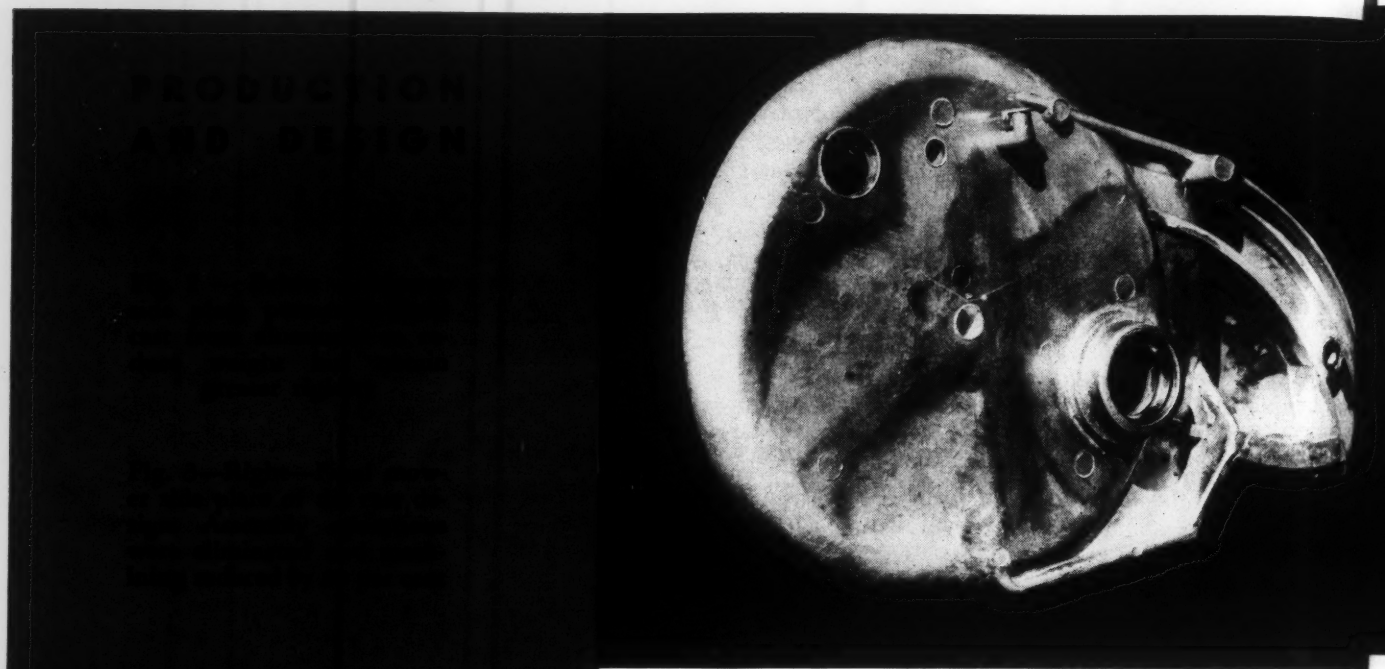
James Samways
*Ass't Chief Engineer*

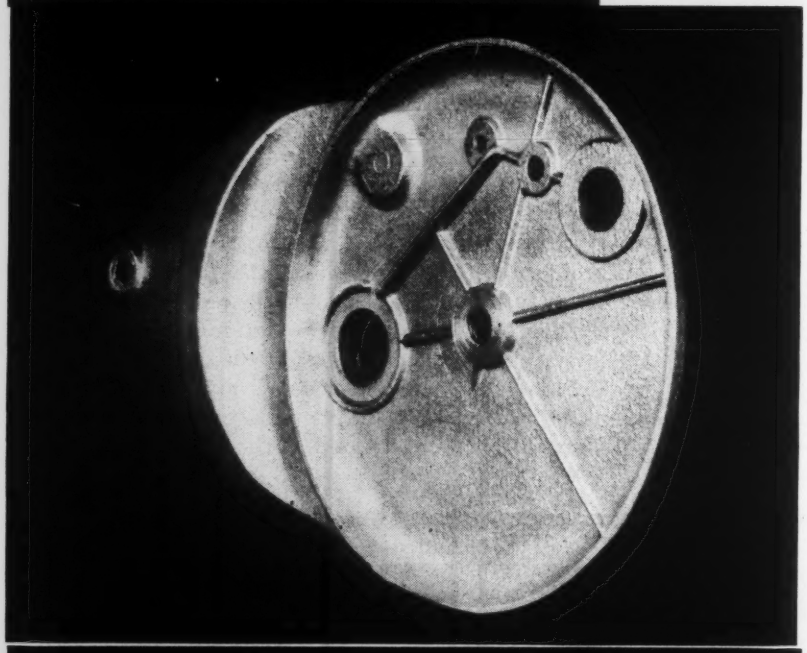
*Toro Mfg. Corp.*
*Minneapolis, Minn.*

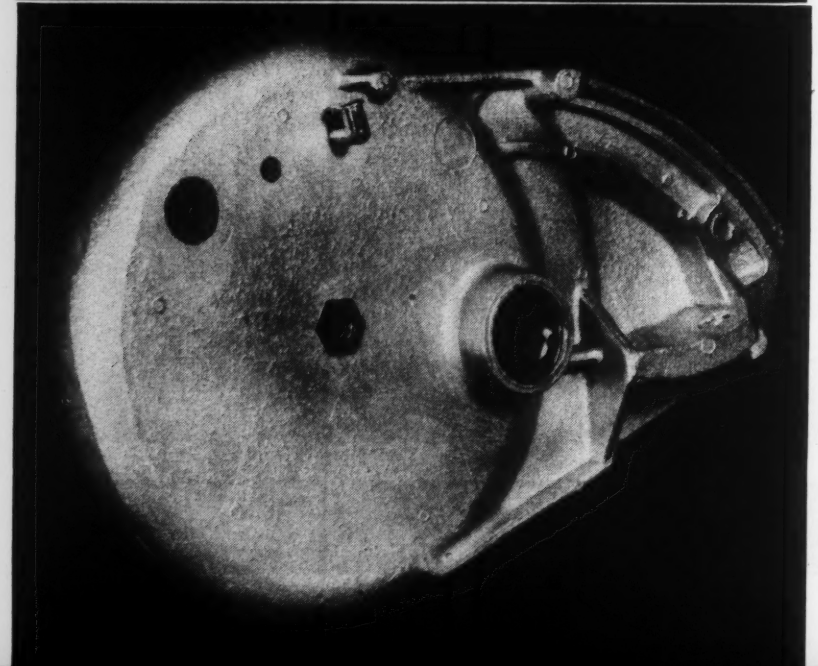
IN 1946 Toro decided to go into the small power lawn mower business. After a thorough market analysis it became apparent that there would be an expanding demand for good, low-priced power lawn mowers. Since this was a new line of equipment for Toro, it was necessary to start designing from scratch. To do this, we compiled a list of specifications of which the primary requisites were: ease of operation, ease of maintenance, low cost, lightness in weight, and styling. Investigation of cost and weight factors resulted in some interesting production design problems, the discussion of which may be of interest and value to other design engineers.

The first machine was built with 12-gage steel side members called side plates. These side plates, *Fig.* 1, were ribbed and formed to provide maximum rigidity. However, it was shortly apparent that these parts made from sheet steel were not sufficiently rigid to maintain the necessary cutting accuracy, nor was it possible at that time to obtain the proper deep-draw-







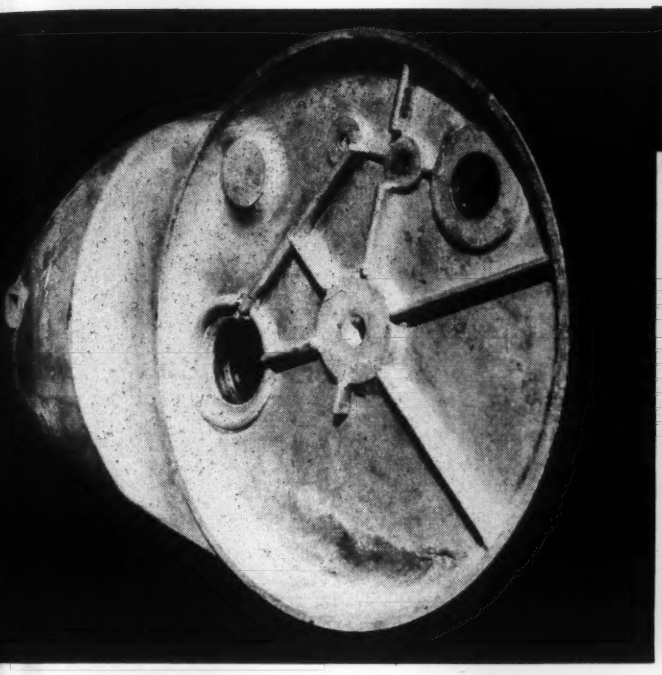


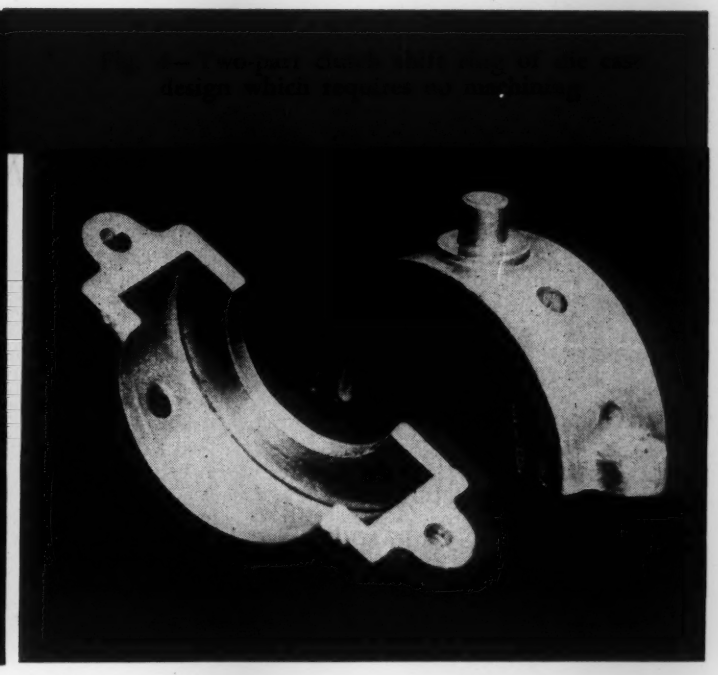
ing sheet steel readily. To make these parts from cast iron would have meant adding approximately 5 pounds to the weight of the machines. Too, machining the cast iron parts would add to the cost and the product would not have the desired finished look due to the rough cast surfaces.

We decided to experiment with permanent-mold aluminum castings which would not only reduce weight but would also reduce the machining cost over iron side plates by approximately 80 per cent, *Fig.* 2. Permanent-mold castings were used the first year of production and were satisfactory with the exception that the surfaces were a bit too rough for a smooth paint finish, and they were not as dimensionally stable as we felt they should be.

One of the major problems which confronted us was that of reducing the weight of the mower so that it could be more easily handled by the owner. It was obvious to us that in order to obtain the desired reduction in weight it was necessary to utilize aluminum; and in order to retail the machine at a price below $100, all possible machining operations had to be eliminated. As a result, pressure die cast aluminum construction was investigated.

The aluminum alloy selected for the side plates, wheels and slip rings is a 4 per cent copper and 11 per cent silicon aluminum-base alloy, with an as-cast tensile strength of 42,000 to 46,000 psi, a yield strength of 24,000 to 28,000 psi, and a 2 per cent elongation. It is an alloy found excellent for both intricate





castings and also for castings requiring high wear resistance and heavy abuse. It also possesses excellent corrosion resistance and can be finished by polishing, painting, or nickel or chrome plating.

The die castings, produced by the Char-Lynn Co., were very successful, *Fig.* 3. The structure of the metal was very fine grained and uniform. The elongation was excellent. The parts were so uniform that the inspection time was reduced to an absolute minimum. Tolerances were held so closely that the cost of machining operations was reduced by 80 per cent. The final cost of the finished part was reduced by 35 per cent as compared with the original parts manufactured from the 12-gage sheet steel, or compared with the estimated cost of the proposed cast iron side plate.

Another part on this particular machine which was die cast was the clutch shift ring, *Fig.* 4. This was a natural application of die casting, as all machining operations were eliminated. The estimated cost of making this particular part of cast iron or brazed steel was $0.41. The finished part produced by pressure die casting amounted to $0.092, a better than 75 per cent reduction in cost.

## Hex Nuts Flame-Cut to Shape

GIANT size hex nuts for a 250-ton hydraulic press are cut to shape by the oxyacetylene cutting process at General-American Transportation Co. The Oxweld blowpipe slices through the 24-inch thick low-carbon steel billet at a rate of 3 inches per min. A hole is first cut out of the center of the block, and sides are then cut in the shape of a hexagon. After being cut to shape, the hex nuts are threaded for column bolts. No other machining is necessary to complete the parts.

"World War II demonstrated that the industries on which national defense depends cannot be left for development until war begins. They must be potentially 'in being', and with plans for their employment. Thus it can be seen that mobilization for defense must be a *continuing* part of our economy and not merely an emergency measure—a program which must be merged with our economic system as a whole."—MILTON W. ARNOLD, *brigadier general, Air Transport Association*

# Protecting Trade Secrets

***Every employee has an obligation to keep trade secrets confidential. But what constitutes a trade secret, and how much information may an employee use to his own advantage?***

*By Albert Woodruff Gray*
*Jackson Heights, L. I.*
*New York*

EMPLOYEES must not disclose trade secrets learned through the confidence placed in them by their employer, asserted the highest court of New York State in a famous decision.

In that state, a manufacturer of printed fabric possessed a secret for the construction of a machine for weaving "jeweled" cloth.

> . . . a man's aptitude, skill, dexterity, manual ability and such knowledge as he obtains in the course of employment are not the property of his employer . . .

After a year and a half of employment, an employee to whom the manufacturer had disclosed this secret organized his own silk printing company and began building similar machines.

When several hundred yards of cloth had been produced by this employee, the former employer applied to the courts to stop the construction and use of these machines and the disclosure of the secret of their construction. The New York court rendered a judgment prohibiting both the building and use of the machines.

The primary point, said the court, is that the duty of an employee to hold in confidence any knowledge of trade secrets acquired during his employment is an essential feature of the relation of employer and employee. It is an absolute duty that exists after the employment as well as during the time of employment.

It must be borne in mind, however, that this principle of law only applies when the secret has been given in confidence, and its disclosure is the consequence of a breach of the confidence entrusted to the employee.

A Pennsylvania firm developed a machine for the manufacture of paper clips. A draftsman was employed to make blueprints for the building of similar machines, but no agreement was made that the information given him should be confidential. Later the man was discharged. He took with him sketches of these machines and found employment with a competitor where he proceeded to construct similar machines. When the machines were placed on the market, the former employer sued to prohibit either the manufacture or use of such machines, or the sale of their product.

Here, said the Pennsylvania court, deciding in favor of the employee, the employee had not agreed to keep the details of the machine secret. The court further said, "The experience, knowledge, memory and skill which he had gained he had a right to use to his own advantage."

Before a court will prohibit the disclosure of trade secrets, however, a trade secret must be involved. "A man's aptitude, his skill, his dexterity, his manual ability and such other knowledge as he obtains in the course of his employment are not the property of his employer and the right to use and expand

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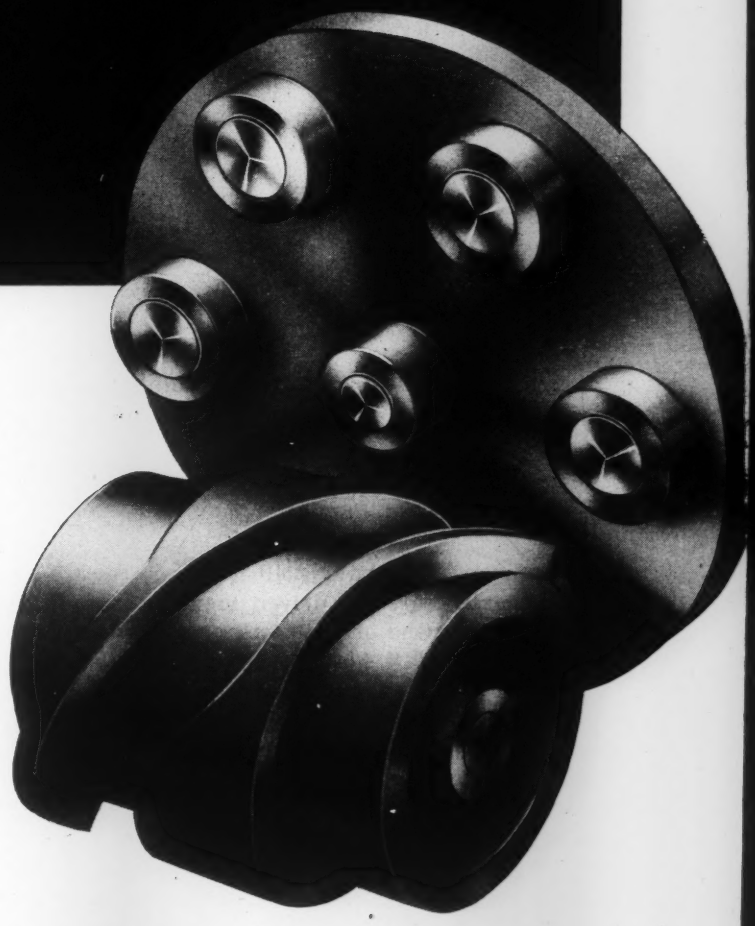
# MECHANISMS FOR INTERMITTENT MOTION

By Otto Lichtwitz
*Mechanical Engineer*
*London, England*

**Part 4**



IN THE first three parts of this series, only gears connecting parallel shafts have been considered, comparable to spur gears for uniform motion. Just as uniform-motion gearing for nonparallel shafts involves special considerations, even more so do intermittent-motion gears for intersecting and crossing shafts.

**Intermittent Gears for Intersecting Shafts:** The design of bevel gears for uniform motion is based on spur gears. The back cones of the bevel gears are in well known manner imagined to be replaced by their tangential planes. The shape at the large end is then found as for spur gears, and the teeth are made converging toward the apex.

It could be expected that bevel gears for intermittent motion should be laid out in an analogous way. However, different factors arising from the intermittent characteristic preclude similar procedures. In conventional bevel gears, meshing takes place in the proximity of the central position, where the cones practically coincide with the tangential planes. On the other hand, the most important parts of intermittently working gears—those for the start and the end of motion—are working at a considerable distance from the central position. Replacing the cones by the tangential planes would be objectionable, and designing and machining such gears would be difficult and expensive.

The best policy, therefore, is to avoid intersecting shafts for transmitting intermittent motion. If such conditions cannot be circumvented, bevel gears similar to those shown in *Fig.* 40 can be applied.

The large gear of that mechanism, the driving member, has 16 teeth, spaced by 15 normal gaps; the 16th gap is abnormal since it occupies more than half the circumference. Design of the gear corresponds

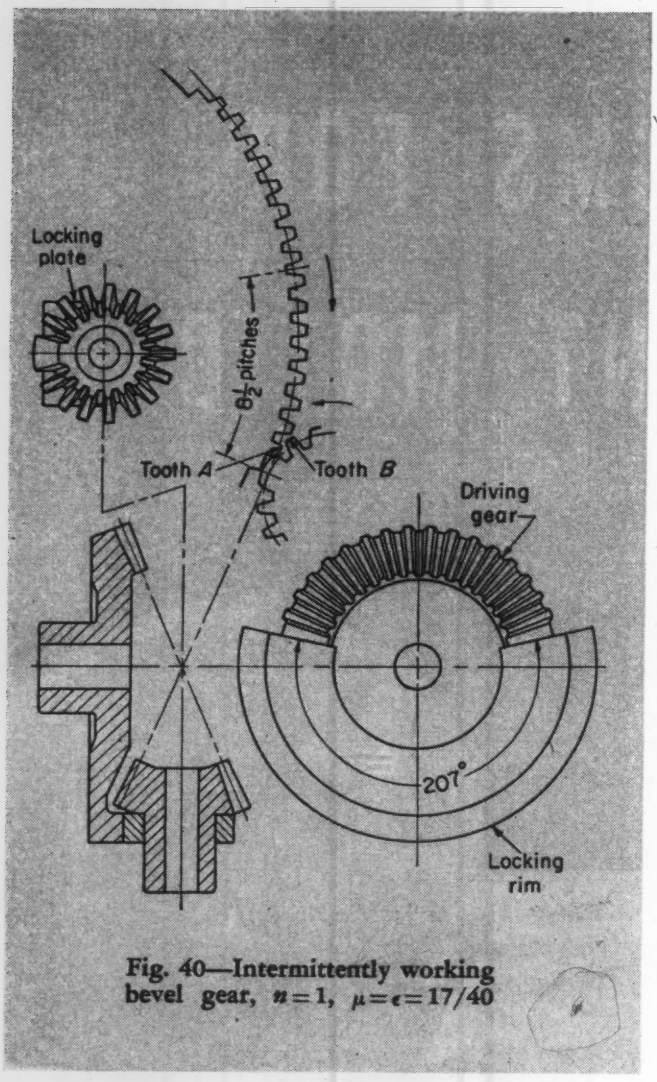



**Fig. 40—Intermittently working bevel gear, $n=1$, $\mu=\epsilon=17/40$**

to a complete gear having 40 teeth.

The small gear, the driven member, has 16 teeth and 16 gaps. One of the teeth occupies the space of two normal teeth. Actually the gear is like one with 17 teeth, one gap not being cut.

During a part of one revolution of the driving gear, the driven gear makes one revolution, and the gears behave during the period of motion like gears of the ratio 40/17.

The standstill is secured by the rim of the driving gear which locks the plate, connected to the driven gear.

Accelerating and retarding elements are omitted because of the difficulties previously explained. The first impulse is given by tooth *A* of the driving gear. That tooth is shortened so that it can pass tooth *B* of the still stationary driven gear. The last tooth of the driving gear is likewise shortened, as it must pass a tooth of the locked driven gear.

At the commencement of motion, the central gap of the 16 teeth of the driving gear is $8\frac{1}{2}$ pitches before the central position of engagement. At the conclusion of motion, the central gap is $8\frac{1}{2}$ pitches beyond the central position. The motion thus occupies $2(8.5/40) = 17/40$ of one revolution of the driving gear, and the locking rim occupies $(23/40)\ 360$ deg = 207 deg.

In spite of only 16 teeth, both $\epsilon$ (the ratio of the angles covered by driving and driven gear during the period of motion) and $\nu$ (the proportion of motion in one cycle) are equal to $\mu = 17/40$. That is, they are equal simply to the ratio of the numbers of teeth of the complete bevel gears.

For high numbers of teeth of the driving gear, it may be found that two teeth on either side of the driving gear must be shortened to enable them to pass the driven gear. Another possibility in such cases is to make the abnormal tooth of the driven gear as a threefold tooth by omitting to cut two gaps. Only one tooth on either side of the driving gear needs then to be shortened. The functioning of the gears is not affected by that modification.

As pointed out in the foregoing discussion, $\epsilon$ is equal to the ratio of the numbers of teeth of the complete driven and driving gears, and the mechanism behaves in the period of motion like a pair of complete bevel gears. It follows that $\epsilon$ never can reach the value 1, because both gears would rotate uniformly. There is no lower limit for $\epsilon$, and it can be chosen as low as required, provided that the space for the resulting large driving gear is available.

It is also possible to provide several locking plates on the driven gear, and to impart only a fraction of one revolution to the driven gear. (With $n$ equally spaced locking plates, $\nu = \epsilon/n$.)

The driving gear can also be equipped with more than one group of teeth, and with more than one locking rim.

Gears such as these described for intersecting shafts render good service at low speeds. However, their kinematic properties do not stand critical investigation and they are not suited for high-speed service.

**Intermittent Gears for Crossing Shafts:** Crossing or skewed shafts (nonintersecting) can be connected by intermittently working gears, though on principles other than those applicable for parallel-shaft gearing. The driving member of the gear shown in *Fig.* 41 is virtually a cylindrical or drum cam which drives the followers mounted on the disk of the driven member.

The drum has a ridge which extends over more than the circumference, and which engages the rollers. A part of the ridge is in a plane perpendicular to the axis of the drum. Its width is equal to the distance between the rollers, and it serves for locking the driven disk. The two ends of the ridge are curved outward, and the distance of the two branches there is equal to the diameter of the rollers, or slightly more. The driven gear is rotated by the interaction of the curved portion of the ridge with the rollers. As the ridge thus serves both for moving and for locking, it ensures a positive movement of the driven member.

The rollers should actually be conical, with the apex on the axis of the drum. Cylindrical rollers are simpler, and do not noticeably increase wear if they are short.

For Geneva mechanisms, the course of movement

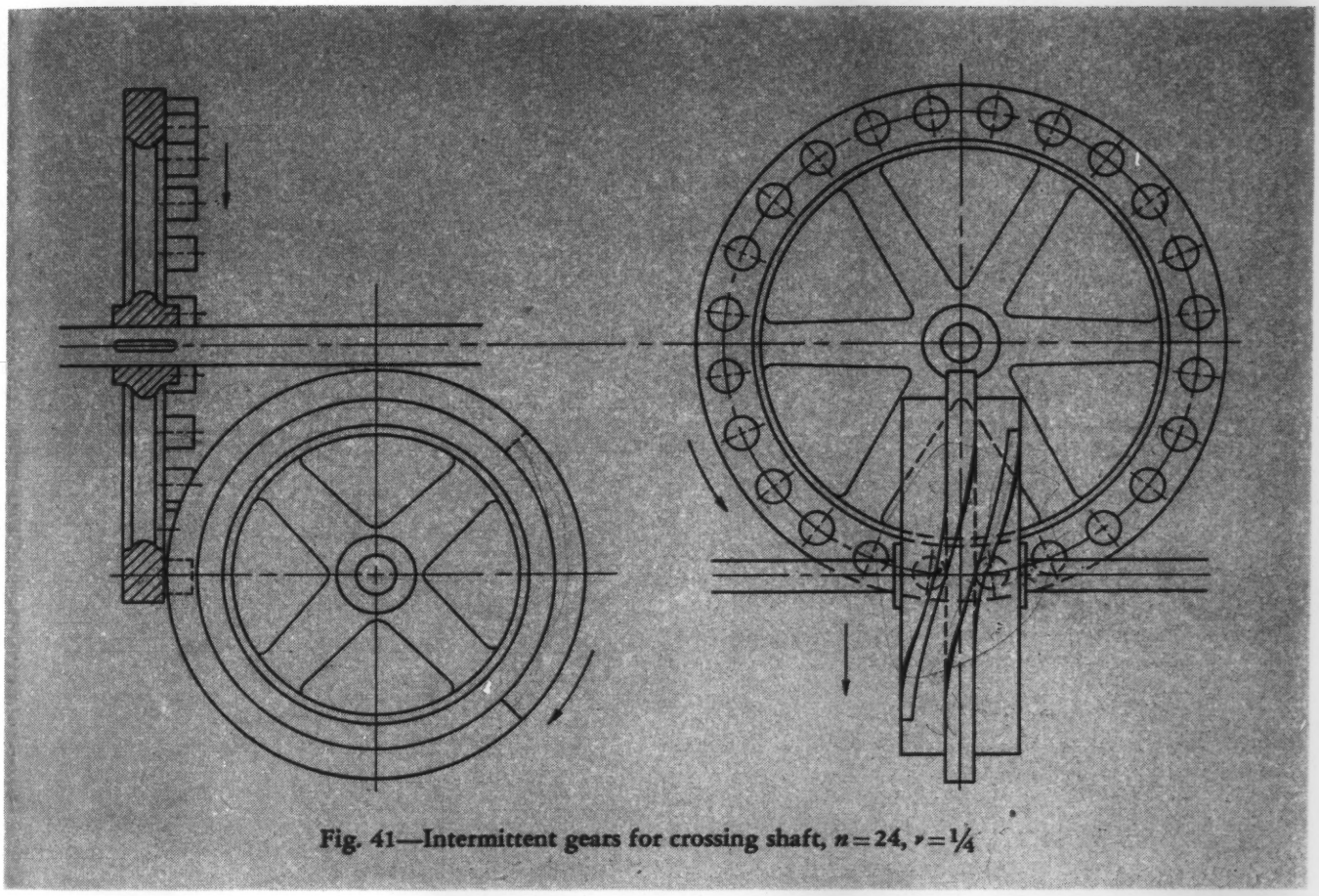


Fig. 41—Intermittent gears for crossing shaft, $n=24$, $\nu=1/4$

is determined by the mere choice of the partial movement, that is, by the choice of $n$. For star wheel mechanisms, either the ratio $\mu$ or the ratio $\epsilon$ can be chosen in addition to the partial movement. Intermittent gears for crossing shafts leave the still further freedom of selecting arbitrarily the course of movement. The lay out of such gears is, therefore, based on considerations of kinematics.

There are two well established methods in cam design, one in imparting to the follower a uniformly accelerated and retarded motion, and one in imparting a harmonic motion.

The cams for the purpose under consideration can also be laid out as cycloidal cams, a form which has been in recent years dealt with in the literature. In this case, the maximum acceleration exceeds that of the two groups discussed here; however, in contrast to the cams of these two groups, the acceleration at the start and at the end of motion is zero. Further characteristics to be outlined here only for the uniform acceleration and the harmonic forms can also be applied with modifications for the cycloidal.

If the proportion of motion in one revolution of the driving gear is called $\nu$, the motion occupies the angle $2\pi\nu$ of the driving gear. With $n$ rollers, one partial movement of the driven disk is $2\pi/n$. *Fig.* 42 shows, for the same angle $2\pi\nu$ of the driving cam, and for the same angular displacement $2\pi/n$ of the driven disk, the diagrams of the two motions. The full line for the angle $\beta$ consists of two branches of parabolas, and pertains to the uniformly accelerated and retarded motion; the dotted line for the angle $\beta$ is a part of a sine curve, and pertains to the harmonic motion.

The angular velocity $d\beta/d\alpha$ has in both cases a maximum at the central position; the value there is lower for the sine curve.

The angular acceleration $d^2\beta/d\alpha^2$ has, in the case of uniformly accelerated and retarded motion, a constant value which in the central position suddenly changes into a constant angular retardation of the same amount. In the case of harmonic motion, the angular acceleration appears as a continuous curve, with a gradual transition from positive to negative values. The extreme values are, however, higher than the constant values in the uniformly accelerated and retarded motion. Both types of motion thus have merits.

If the lower left-hand corners in *Fig.* 42 are considered as the origin of the graphs, the equation of the left-hand branch of the parabolas is $\beta = c\alpha^2$, and the constant $c$ is obtained by correlating, for the central position, $\alpha = \pi\nu$ with $\beta = \pi/n$. That is, $\pi/n = c\pi^2\nu^2$, or $c = 1/\pi n\nu^2$, so that

$$\beta = \frac{1}{\pi n \nu^2}\alpha^2 \qquad (54)$$

If unit angular velocity of the driving cam is as-

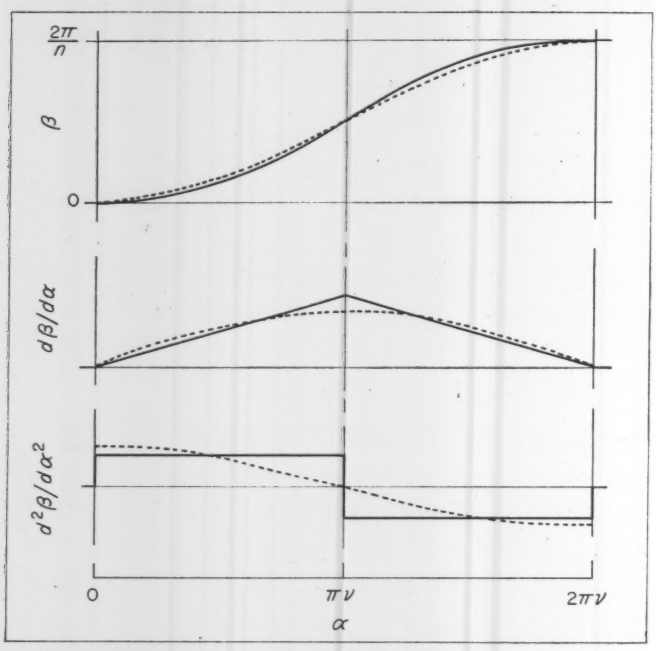



Fig. 42—Diagram of motions for intermittent gears connecting crossed shafts

sumed, the numerical value of the angular velocity of the driven disk is

$$\frac{d\beta}{d\alpha} = \frac{2}{\pi n \nu^2} \alpha \quad \ldots\ldots (55)$$

and the angular velocity in the central position ($\alpha = \pi\nu$) is

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{2}{n\nu} \quad \ldots\ldots (56)$$

The angular acceleration and retardation have the constant value

$$\frac{d^2\beta}{d\alpha^2} = \frac{2}{\pi n \nu^2} \quad \ldots\ldots (57)$$

Again with the lower left-hand corner as the origin of the graph, the equation for harmonic motion is $\beta = c(1 - \cos c'\alpha)$, wherein $c$ and $c'$ are constants to de determined. At the end of motion, $c'\alpha = 2c'\pi\nu = \pi$, so that $c' = 1/2\nu$. Also, at that instant $\beta = 2\pi/n$. It follows that $c(1 - \cos\pi) = 2\pi/n$, or that $c = \pi/n$. The relation between $\beta$ and $\alpha$ is, therefore,

$$\beta = \frac{\pi}{n}\left(1 - \cos\frac{\alpha}{2\nu}\right) \quad \ldots\ldots (58)$$

The angular velocity is

$$\frac{d\beta}{d\alpha} = \frac{\pi}{2n\nu} \sin\frac{\alpha}{2\nu} \quad \ldots\ldots (59)$$

and its amount in the central position is

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{\pi}{2n\nu} \quad \ldots\ldots (60)$$

The angular acceleration is

$$\frac{d^2\beta}{d\alpha^2} = \frac{\pi}{4n\nu^2} \cos\frac{\alpha}{2\nu} \quad \ldots\ldots (61)$$

and its maximum, at $\alpha = 0$, is

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{max} = \frac{\pi}{4n\nu^2} \quad \ldots\ldots (62)$$

A comparison between Equations 56 and 60 shows that the ratio of the maximum angular velocities for

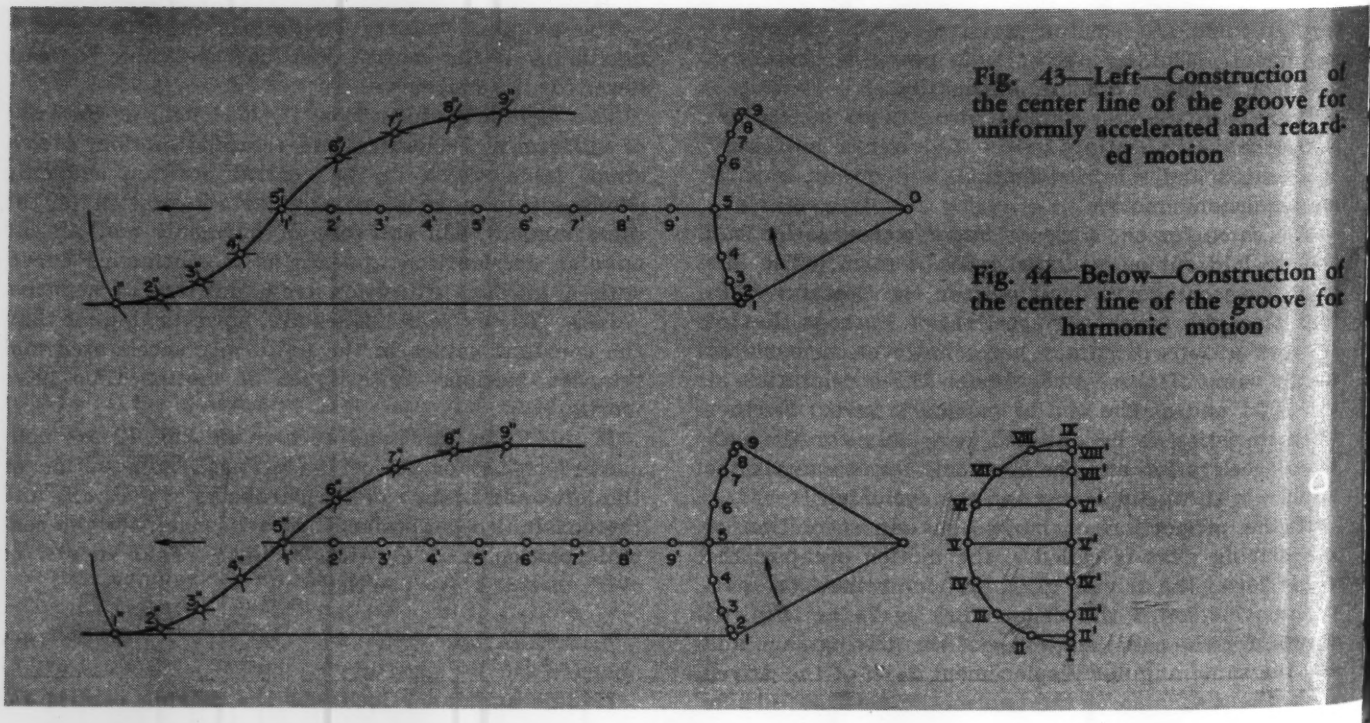


Fig. 43—Left—Construction of the center line of the groove for uniformly accelerated and retarded motion

Fig. 44—Below—Construction of the center line of the groove for harmonic motion

harmonic, and uniformly accelerated and retarded motion is

$$\frac{\frac{\pi}{2\,n\,\nu}}{\frac{2}{n\,\nu}} = \frac{\pi}{4} = 0.7854$$

A comparison between Equations 57 and 62 shows that the ratio of the maximum angular acceleration for harmonic, and uniformly accelerated and retarded motion is

$$\frac{\frac{\pi}{4\,n\,\nu^2}}{\frac{2}{\pi\,n\,\nu^2}} = \frac{\pi^2}{8} = 1.2337$$

EXAMPLE 13: Investigate the kinematic properties of intermittent gears for crossing shafts, with $n = 6$ rollers, and $\nu = \frac{1}{2}$, for the angular velocity of the driving gear $\omega = 1$ rad per sec.

*Uniformly accelerated and retarded motion:* The maximum angular velocity, Equation 56 is $2/(6\times\frac{1}{2}) = 0.667$ rad per sec. The angular acceleration and retardation, Equation 57, are $2/(\pi \times 6 \times \frac{1}{4}) = 0.424$ rad per sec$^2$.

*Harmonic motion:* The maximum angular velocity, Equation 60, is $\pi/(2\times6\times\frac{1}{2}) = 0.524$ rad per sec. The maximum angular acceleration, Equation 62, is $\pi/(4\times6\times\frac{1}{4}) = 0.524$ rad per sec$^2$.

If there is a large number of rollers, the developed curve along which the centers of the rollers are moving relatively to the driving cam resembles the two parabolas or the sine curve, and the developed contours of the ridge are obtained in the envelope of circles with the centers on that curve and of the diameter of the rollers. The construction of the parabolas or the sine curve follows well known methods.

In cases of small numbers of rollers, it is advisable to construct the developed center line of the groove more exactly, as shown in *Figs.* 43 and 44.

If the motion is intended to be uniformly accelerated and retarded, the arc 1-9, *Fig.* 43, along which the rollers travel in one partial movement is divided into, for instance, 32 (generally $2x^2$) equal parts; the arcs 1-2 and 9-8 are made one of these parts, the arcs 2-3 and 8-7 three parts, the arcs 3-4 and 7-6 five parts, and the arcs 4-5 and 6-5 seven parts.

The distance 1′-9′ is made equal to the developed circumference of the part of the driving cam during which motion takes place, and it is divided into 8 (generally $2x$) equal parts. A circle of the pitch radius of the rollers and with the center at the point 1′, and a straight line parallel to 1′-9′ through the point 1 intersect in the point 1″. This and similarly constructed other points determine the developed center line of the groove.

If a harmonic motion is required, a circle is scribed the diameter I-IX equal to the rectified arc 1-9 (*Fig.* 44), along which the rollers travel in one partial movement. Half of the circle is divided into 8 equal angular parts, and the points II, III, etc., projected on the diameter I-IX. The arc 1-9 is now divided into 8 parts by making the arc 1-2 equal to I-II′, the arc 2-3 equal to II′-III′, etc. The construction of the center line of the groove is otherwise the same as described before.

The previous equations show that the kinematic properties are independent of the diameter $d_1$ of the driving cam, of the pitch diameter $d_2$ of the driven disk, and of the diameter $d$ of the rollers. These di-

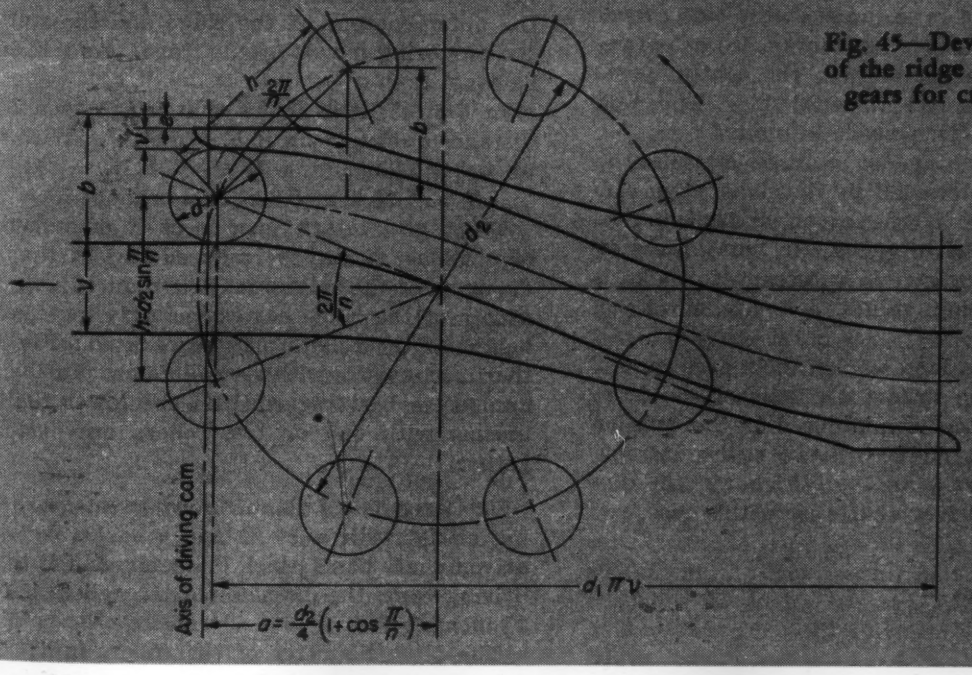



Fig. 45—Developed contour of the ridge of intermittent gears for crossing shafts

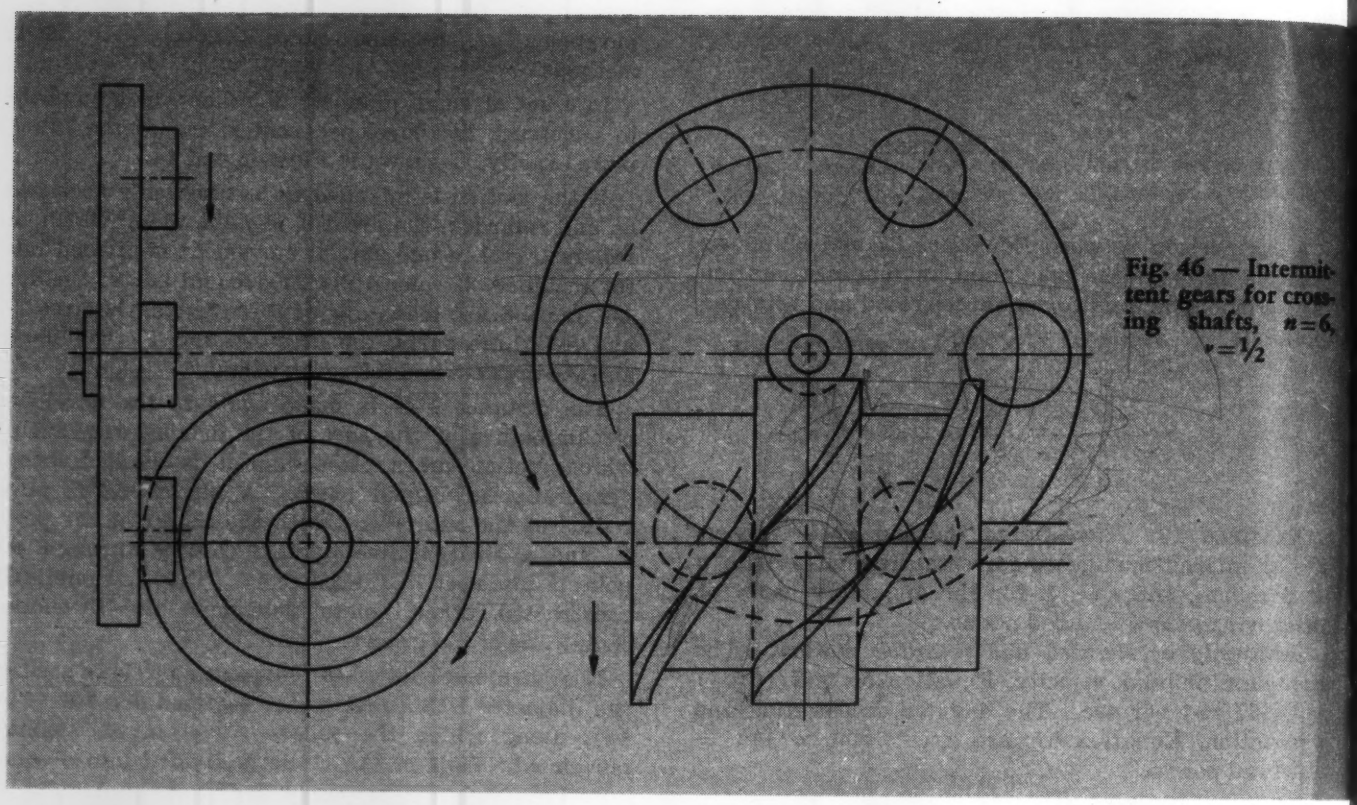


Fig. 46 — Intermittent gears for crossing shafts, $n=6$, $\nu=1/2$

mensions can be chosen arbitrarily, and the following guide may assist in design.

A large diameter $d_1$ reduces the inclination of the ridge, and since that inclination has a similar significance as the angle of a wedge, or as the helix angle of a screw thread, the pressure between the cam and the followers decreases with increasing diameter $d_1$.

The length of the curved portion of the ridge in *Fig.* 45 is $d_1\pi\nu$, corresponding to the angle $2\pi\nu$ in the graphs of *Fig.* 42. The lift of the cam is $d_2 \sin \pi/n$, corresponding to the angle $2\pi/n$ in *Fig.* 42. If $d_1\pi\nu \div (d_2 \sin \pi/n)$ is about 4 in the case of the sine curve, and about 5 in the case of the two branches of parabolas, the maximum inclination (in the central position) is in both cases less than 22 deg. The sine curve, thus, is preferable if space is limited.

The mentioned advantage of a large diameter $d_1$ is in some cases counteracted by disadvantages. If, for instance, $d_1$ exceeds $d_2$, the driven shaft cannot be extended beyond the driving gear. In many cases of small values for $\nu$ and $n$, it is necessary to make a compromise by reducing values $d_1\pi\nu/(d_2 \sin \pi/n)$ recommended above.

As the rollers move along an arc, their axes cannot point in every position toward the axis of the driving cam. The influence is minimized if the axis of the driving shaft lies midway between the extreme positions of the rollers. As *Fig.* 45 shows, the distance of driving and driven shafts is, in this case,

$$a = \frac{1}{2}\left(\frac{d_2}{2} + \frac{d_2}{2}\cos\frac{\pi}{n}\right) = \frac{d_2}{4}\left(1 + \cos\frac{\pi}{n}\right) \quad \text{(63)}$$

Further, *Fig.* 45 shows that chord $h = d_2 \sin \pi/n = d + r$.

If the diameter $d$ of the rollers, and the thickness $r$ of the ridge are assumed to be equal, $2d = 2r = d_2 \sin \pi/n$, or

$$\frac{d}{d_2} = \frac{r}{d_2} = \frac{1}{2}\sin\frac{\pi}{n} \quad \text{(64)}$$

The thickness $r'$ at the ends of the ridge must be kept so small that there is no interference between the outer contour of the ridge and the roller behind the one being moved by the ridge. As a guide, $r'$ may be equal to $d/4$.

In *Fig.* 45, it is shown that $b/h = \cos 2\pi/n$. The distance $e$ disappears if $b = d + r'$. With $r' = d/4$, or $b = 1.25\ d$, and $h = d + r = 2d$, $\cos 2\pi/n = b/h = 1.25/2 = 0.625$, or $n$ is about 7.

To prevent interference in cases of a small number of stations, $r'$ may be reduced to less than $d/4$, the diameter of the rollers may be reduced and the thickness $r$ of the ridge correspondingly increased, or the height of the rollers may be reduced. *Fig.* 46 shows that mechanisms with six rollers are possible, but that number is best regarded as the lower limit. Mechanisms with one or two rollers are excluded altogether.

EXAMPLE 14. Lay out intermittent gears for crossing shafts with $n = 24$ and $\nu = \frac{1}{4}$ (*Fig.* 41). The driven shaft has $1\frac{1}{2}$-inch diameter, and is to cross the driving cam; the diameter of the rollers is to be $d = 1\frac{1}{4}$ inches.

The pitch diameter of the rollers is $d_2 = 2(1.25) \div (\sin 7\frac{1}{2}$ deg) $= 19.153$ inch, according to Equation

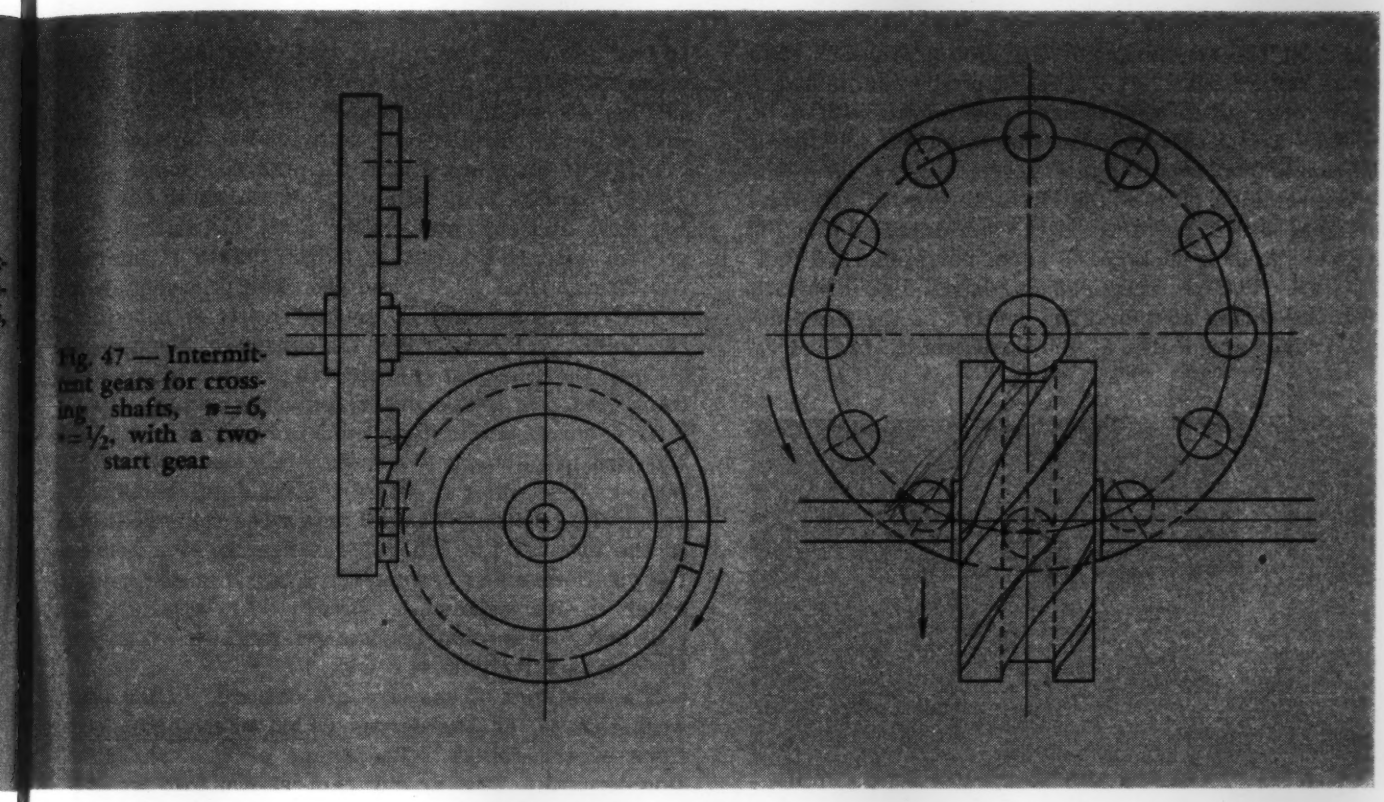


Fig. 47 — Intermittent gears for crossing shafts, $n = 6$, $\nu = \frac{1}{2}$, with a two-start gear

64. As the ridge may be thinner than $1\frac{1}{4}$ inches, $d_2$ may be assumed somewhat smaller, for instance 18 inches. The chord is, in this case, $h = 18 \sin 7\frac{1}{2}$ deg $= 2.350$ inches, and the thickness of the ridge is $r = 2.350 - 1.250 = 1.100$ inches.

The distance of driving and driven shaft is, according to Equation 63, $a = (18/4)(1 + \cos 7\frac{1}{2}$ deg$) = 8.961$ inches. There is no objection against rounding it off to 9 inches. The axis of the driving shaft then does not lie midway between the extreme positions of the rollers, but rather touches the pitch circle of the rollers.

The diameter of the driving cam must be smaller than $2a - 1.5 = 2(9) - 1.5 = 16.5$ inches, in order to let pass the driven shaft. It may be made 16 inches.

The ratio $d_1\pi\nu/(d_2 \sin \pi/n) = 16(\pi)(\frac{1}{4})/2.350 = 5.349$, and indicates that either a uniformly accelerated and retarded, or a harmonic motion can be applied. With the lift of the cam equal to 2.350 inches, and the developed length $16\pi/4 = 12.566$ inches, the maximum of the wedge angle is, for uniformly accelerated and retarded motion, 20 deg 30 min, since $2(2.350)/12.566 = \tan 20$ deg 30 min. For harmonic motion, it is 16 deg 22 min, since $2(2.350)/16 = \tan 16$ deg 22 min.

The proportion of motion in one revolution of the driving gear can be chosen to suit any requirements between $\nu_{max} = 1$ and $\nu_{min} = 0$, corresponding to $\epsilon_{max} = n$ and $\epsilon_{min} = 0$. In the former case, the ridge of the driving cam is curved throughout, and the driven gear is periodically slowed to zero velocity, without remaining at rest. In the other extreme case, the driving gear is plane, and works like a rack.

The basic principle of the mechanisms previously considered can be modified in several ways. For instance, the cam can be laid out in a way where the ridge has more than one straight and one curved portion, so that the driven gear makes more than one partial movement during one revolution of the driving gear. Duration of the partial movements can be varied in this case. It is also possible to obtain somewhat varying partial movements.

In the previous considerations, it has been assumed that one roller is guided between the flanks of two branches of the ridge, and that the straight part of the ridge is locking while running between two rollers. The arrangement can be inverted, without departing from the idea of the mechanism, in such a way that two rollers are guided by the curved ridge, and that two straight branches of the ridge serve for locking.

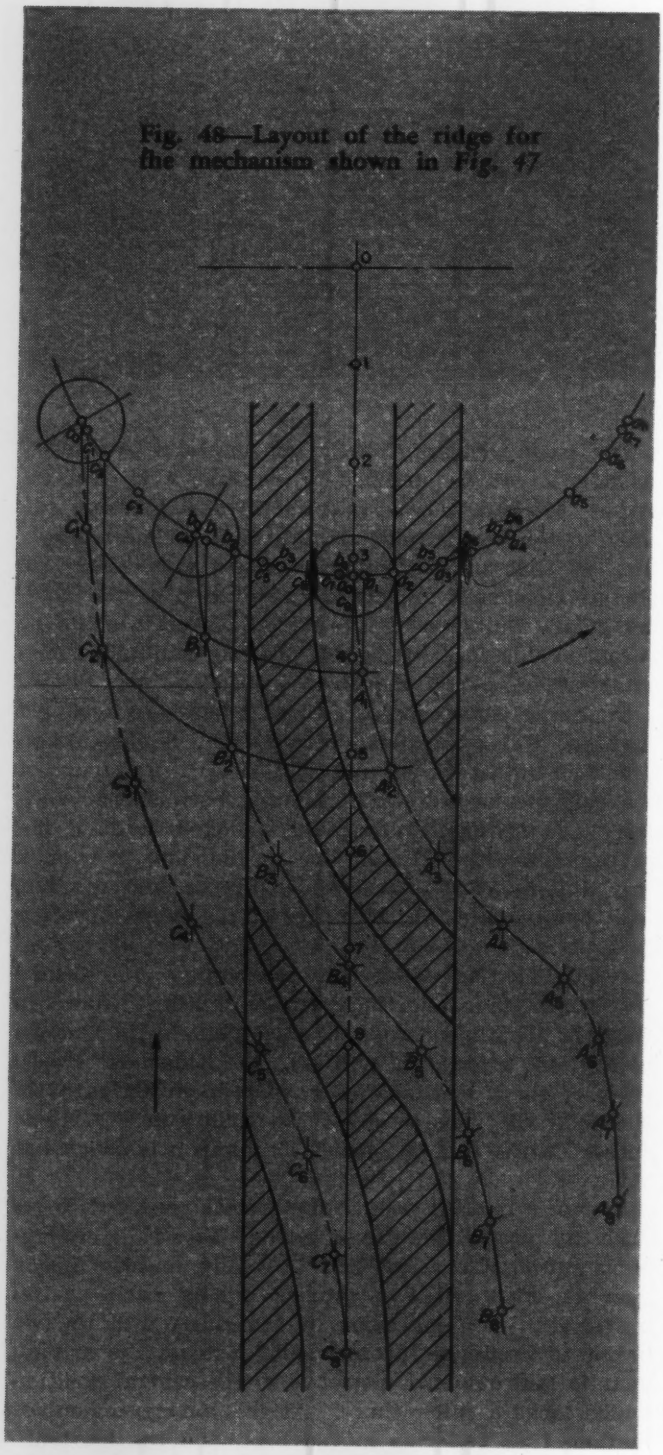
A modification which has no analogy in intermittent gears for connecting parallel shafts is shown in *Fig.* 47. This mechanism is equivalent to that shown in *Fig.* 46, as $n = 6$, and $\nu = \frac{1}{2}$. Kinematic conditions of these mechanisms have been investigated in Example 13. The pitch of the rollers in *Fig.* 46 is rather coarse, and the whole mechanism is somewhat bulky.

In worm gearing, multistart worms are used to reduce the pitch. The driven gear of *Fig.* 47 is analogously equipped with $2(6) = 12$ rollers, and the driven gear is advanced two pitches during each partial movement. A duplication of the ridge with its two branches would be inconvenient; instead, the driving gear is laid out with a groove in the central position which locks a roller there. At the commencement of motion, that roller is moved first, and the two sub-

sequent rollers enter successively the grooves of the cam. At the conclusion of the motion, the first two active rollers have left the reach of the cam, and the third roller is in the central position, ready to be locked. The construction of the developed contour of the cam is demonstrated in *Fig.* 48.

The rectified part of the circumference of the driving cam which pertains to the period of motion, is divided into, for instance, 8 equal parts, marked 0, 1, 2, . . . 8. The pitch circle of the driven disk is scribed with the center at 0, and the centers of the three active rollers are drawn at the positions $a_0$, $b_0$, and $c_0$, at the commencement of motion. The arc $a_0a_8$, equal to two pitches of the rollers, is divided into 8 unequal parts marked $a_1$, $a_2$, etc., obtained in the way shown in *Figs.* 43 and 44. The path of the second roller $b_0b_8$, and of the third roller $c_0c_8$, is divided in the same way.

Fig. 48—Layout of the ridge for the mechanism shown in *Fig.* 47



Straight lines are drawn through the points $a_1$, $b_1$ and $c_1$, parallel to the direction of motion of the driving cam, and the pitch circle of the driven rollers is scribed with the center at 1; the points of intersection are marked $A_1$, $B_1$ and $C_1$. The procedure is repeated for the points 2 to 8. The lines connecting the points *A*, *B*, and *C*, are the centers of the grooves.

Only the roller in the central position is supposed to be guided in the period of standstill, and the driving gear is correspondingly assumed of such a width that the two neighboring rollers are not touched in that period. The roller *B* enters the reach of the cam between the positions 2 and 3, when the roller *A* is still in the groove; the roller *C* reaches the cam between the positions 4 and 5, when the roller *B* is still guided; roller *A* has meanwhile already left its slot. The continuity of motion is thus guaranteed, in spite of the comparatively narrow cam.

The contours of the cam are obtained in the usual way, that is, as the curves which envelop the positions of the rollers. The shape of the cam is unsymmetrical. The actual cam shows two grooves, one for guiding the roller *B*, and one for guiding the rollers *A* and *C*.

Intermittent gears for crossing shafts have several features common with worm or spiral gears. Similarly, as right and left-hand threads are used in these gears to obtain the required direction of motion, the inclination of the ridge of the driving cam can be varied to achieve the same effect. As in worm gearing, the driving shaft can be arranged horizontal, whether a horizontal or a vertical shaft is to be driven. As for worm or spiral gearing, adequate measures must be adopted for taking up the axial thrust of the gears.

**Comparison of Intermittent Gears:** The movement of an intermittently rotating shaft is specified by the partial movement (or by the number of stations *n*), and the ratio of the angles of driving and driven gear during the period of motion.

Equations 3 and 3*a* express, for external and internal Geneva mechanisms, linear relations between $\epsilon$ and *n*. Values of $\epsilon$ in TABLES 2 and 3, plotted in the graph of *Fig.* 49 against *n*, lie on two straight lines, starting at the smallest possible number of 3 stations. Fractional values of *n*, which pertain to some modified mechanisms, are disregarded.

Equations 28 and 28*a* indicate that $\epsilon$ depends, for external and internal star wheel mechanisms, on *n* and on $\mu$, so that there is for any value of *n* a multitude of values $\epsilon$. The upper limit of $\epsilon$ is, according to Equations 30 and 30*a*, equal to *n*, and that limit appears in *Fig.* 49 as a straight line inclined 45 deg. The lower limits of $\epsilon$ are determined by Equations 32 and 32*a*. The values of $\epsilon_{min}$ in TABLES 4 and 7 are plotted in *Fig.* 49, and the lines connecting these points are the lower limits of $\epsilon$.

According to *Fig.* 49, the external star wheel mech-

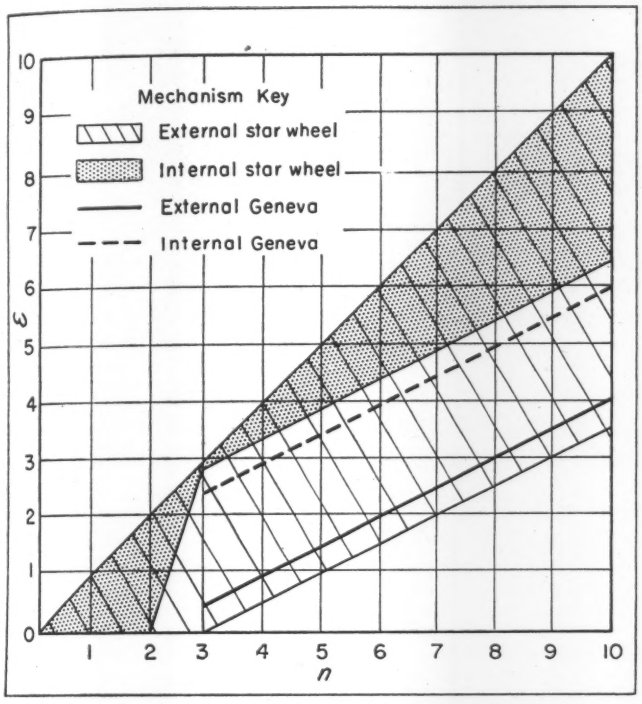



Fig. 49—Ranges of $\epsilon$ versus $\eta$ for Geneva and star wheel mechanisms

anism is the most versatile, since its range comprises those of the three other mechanisms considered here. External Geneva mechanisms, internal Geneva mechanisms, and internal star wheel mechanisms cover different ranges, and they cannot directly replace each other.

External star wheel mechanisms can thus be regarded as a universal means for imparting intermittent motion between two parallel shafts. Internal star wheel mechanisms are not only useful where an internal drive is essential, but also are in many cases simpler than equivalent external star wheel mechanisms as there is a wider scope for dispensing with elements for imparting the uniform motion. External Geneva mechanisms are simple, and are to be applied where the only value of $\epsilon$ for any particular number of stations is suitable. Internal Geneva mechanisms have a rather limited field of application, because the high values of $\epsilon$ can in a restricted number of cases only be reconciled with practical requirements.

The driving member of intermittent gears for crossing shafts can be laid out for any value of $\epsilon$ between 0 and $n$. Intermittent gears for crossing shafts thus have an even wider range than star wheel mechanisms, and can be laid out for the best conceivable kinematic conditions. Nevertheless, they are not competing with Geneva or star wheel mechanisms, because the number of driven rollers cannot be smaller than 3, and practically not even smaller than 6. Star wheel mechanisms, on the other hand, are comparatively simple with one or two locking shoes, and the difficulites and costs rise with increasing number of stations. The latter adversity also applies to Geneva mechanisms.

Provided the arrangement of the shafts is not the decisive factor, the choice between gears connecting parallel and crossing shafts thus depends mainly on the number of stations, and the two groups of mechanisms complement each other. Although there is no hard and fast rule, the following scheme may serve as a guide:

Between 1 and 3 stations, star wheel mechanisms
Between 4 and 6 stations, Geneva mechanisms
6 or more stations, mechanisms for crossing shafts.

The bevel gears treated earlier should only be applied if intersecting shafts cannot be avoided.


**Reprints**

Demand for tear-sheets of "Mechanisms for Intermittent Motion" has far exceeded the supply. To fill the need for copies of this design reference, the entire four-part series is being reprinted as a single 52-page booklet. These reprints may be obtained at $1.00 per copy by writing to Book Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.


# Ingot Buggies Operate Automatically

AUTOMATIC CONTROL system for ingot cars gives a steel mill in Ashland, Ky., the appearance of being an automatic factory. The car, without operator, suddenly moves along its track and stops before one of the many soaking pits. A waiting crane deposits a white-hot ingot on it. Without apparent further direction the ingot buggy proceeds along the track and unloads itself onto the tables before the mill stands. The buggy may then wait, or return to a different pit location for another ingot.

Secret of the Westinghouse control is the use of two parallel, segmented trolley wires. One is contacted by the crane in its travel; the other, with matching segments, provides the buggy control. The two trolley wires form two sides of a bridge circuit. When the crane and buggy are in different locations, the bridge is unbalanced and the resulting current flow controls the buggy drive motors to move the buggy along the track until the unbalance disappears. A separate control unbalances the circuit to make the buggy move to the discharge end.

One of two crane operators actually controls the operation. When the crane is in position over a soaking pit, the operator presses a button, causing the buggy to come to that position and stop. When the buggy is loaded, the operator presses another button, and the buggy travels to the discharge position, whereupon it goes through a sequence of unloading operations, all automatically controlled and sequence-interlocked for safety.

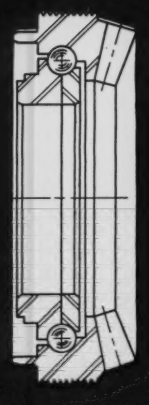


Fig. 1—Unique bearing design for [illegible] outer diameter

# UNGROUND B

*Used in the proper [illegible] these bearings can effectively reduce [illegible] and conserve vital materia*

WHAT IS AN "unground" ball bearing? Although the name tends to imply that no ground parts are used in the bearing, it is an assembly composed of precision ground and polished balls together with hardened raceways having smooth, machined surfaces. Frequently the parts are assembled into and held together by a soft steel outer band or form an integral part of a machine, *Fig.* 1. Because the races are not ground, these bearings are made purposely with greater internal play and broader dimensional tolerances than a precision bearing. In view of these characteristics, unground bearings are used principally in applications where load and speed conditions range from static to medium, and where the maximum in running accuracy is not required.

There are logical and basic reasons for the use of unground bearings. From the engineering standpoint, they are fundamentally suitable for a wide variety of applications wherein the costly refinements of precision bearing tolerances and higher quality materials would be wasted. From the economic standpoint, initial bearing cost is but a fraction of that for a ground bearing of comparable size, and ground shaft and housing fits are unnecessary.

There is another reason which may seem unusual, but it is simply that in many applications unground bearings function better than closely fit bearings. A typical illustration would be the mounting of two standard single-row bearings on a shaft where misalignment is apt to occur. The looser construction of the unground bearing would prevent the bearings from binding as would be the case with precision bearings. Another illustration would be of a bearing mounted in a position where it would be difficult to exclude all foreign particles. Small particles of dirt can cause a precision bearing to bind while the unground bearing having some internal looseness will often operate satisfactorily in spite of dirt and grit.

Unground bearings are usually made to standard inch dimensions to permit mounting on standard shafting without preliminary machining or grinding. Whereas a precision bearing should be mounted into a housing previously machined or ground accurately within a few ten-thousandths, the unground bearing with soft outer band will permit press fits as high as one hundredth of an inch and still turn freely.

**Standard and Special Types:** As a rule, unground bearings are assembled with a full complement of balls which, at slow speeds, enables them to with-

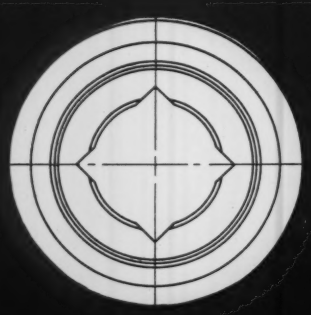


Fig. 2—Broached bore eliminates turning operation required for mounting plain bore bearings on square shafts or axles

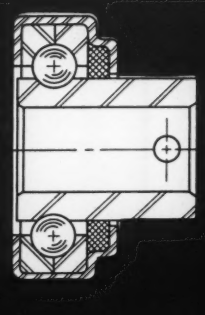
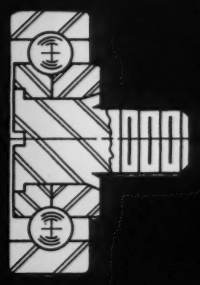


Fig. 3—Extended inner race simplifies assembly by permitting use of pin or set-screw to locate bearing

Fig. 4 — Flanged outer band positions bearing in tubes or housings without shoulder



stand relatively high loads. They are designed for radial loads, thrust loads and angular-contact loads.

Many standard sizes of unground radial, thrust and combination radial-thrust bearings are usually available to select from. Whether the quantities be large or small, standard bearings always possess the advantage of ready availability, so when satisfactory from the standpoint of both cost and suitability, a standard bearing should be specified. However, where sufficient quantities are involved, the machine designer should consider cost savings and other advantages that may be realized by using modified standard or specially designed bearings.

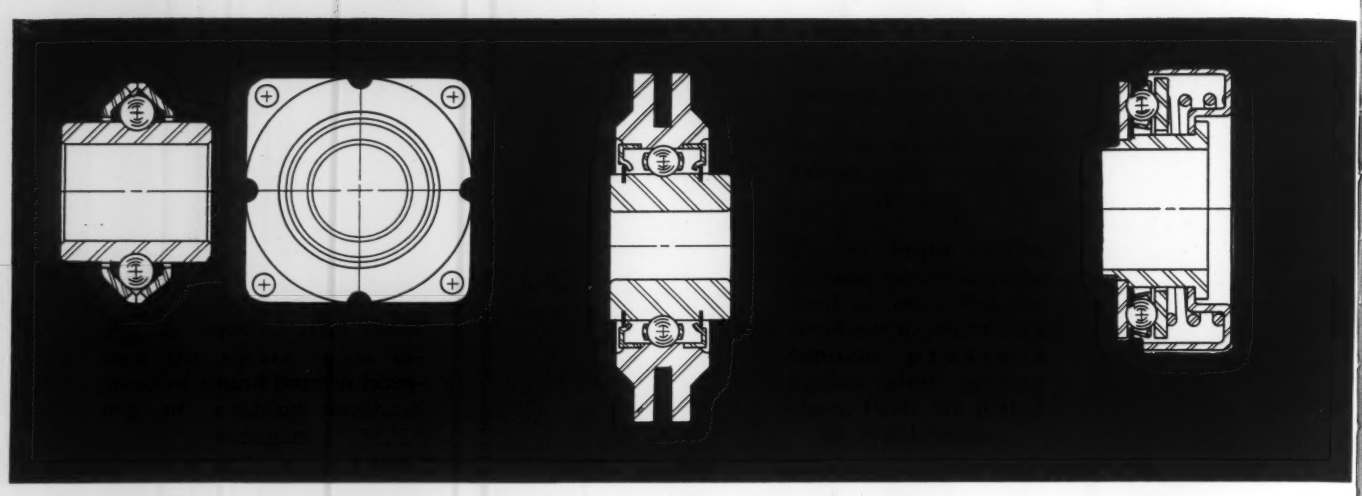
Sometimes a situation may arise in which a standard unground bearing will not quite meet design requirements. Suppose the critical requirement is that the bearing must fit the housing with practically no play and yet be removable by hand; obviously the bearing must have an outside diameter held to close tolerances. The answer is simple; use an unground bearing with the outside diameter finish ground.

In considering such modifications it is well to know which refinement items are expensive and which are inexpensive. Grinding the outside of a bearing to close tolerances is generally a very inexpensive addition. Face grinding to hold width tolerances is also comparatively inexpensive. Grinding the bore is one of the more expensive operations, and costs rise steeply as bore tolerances are decreased. Under certain circumstances a tolerance of 0.001-inch will raise bearing cost but slightly, while a 0.0005-inch tolerance could cause the price of the bearing to double.

Decision to adopt other than standard bearings in any design usually is justified by one or both of two basic reasons: first, to simplify the mounting of the bearing and second, to combine a function of the machine into the bearing. A bearing with a square, *Fig.* 2, or hexagonal bore for use on a square or hexagonal shaft is a representative example of simplified functional mounting. For fastening an extended inner race bearing, *Fig.* 3, to a round shaft, a pin or setscrew is often used. The outer band can be provided with a flange as in *Fig.* 4 to locate the bearing in a tube or housing bore. Also, it can be knurled to provide a good grip when pressed into a housing of hard rubber or nylon, etc. If the bearing is intended for use as a roller, *Fig.* 5, a one-piece hardened outer race is used.

It should be mentioned that variations from existing standards usually require new tooling and quanti-

F. RUSSELL SMITH, now in his twenty-seventh consecutive year of association with Nice Ball Bearing Co., graduated from Girard College, Philadelphia, Pa., in 1925. His scholastic education was supplemented by further study of machine design and related subjects at Temple University. Mr. Smith's experience in ball bearing design, manufacture and application is not confined to unground bearings, for his company also manufactures semiprecision and precision bearings in both conventional and special designs. This year marks the Golden Anniversary of Nice Ball Bearing Co. which has grown and progressed steadily since 1902, and now produces over one million bearings per month.



ties must be sufficient to warrant production. If quantities are small it is usually expedient to adhere to the use of standard bearings, whether they be unground, semiprecision or full precision. However, thorough investigation may disclose that a desired special bearing is similar to some design previously produced and existing tooling may be utilized for even comparatively small quantities. Typical examples of such special constructions are shown in *Figs.* 6 to 8.

**Bearing Materials:** There is practically no limit in the choice of material for unground bearings. To minimize cost, the raceways generally are made from low-carbon steel and hardened after machining. Thin sections are cyanide or salt-bath hardened while heavier sections usually are carburized. If a critical load condition exists the races can be made from chrome-alloy steel and hardened throughout.

In bearing applications where the inner race is stationary and the load is always from one radial direction, wear will occur at one spot on the inner race ball groove. As a result this area is likely to fail first. The outer race which revolves has the wear distributed over the entire ball raceway and consequently it will last longer than the inner race. By making the inner race of a higher quality steel to retard localized wear, the entire bearing will last much longer. The situation would be reversed if the outer race were stationary and in this case the outer ring would be made of the better steel.

Unavoidable exposure to moisture or corrosive conditions is detrimental, of course, to any bearing. An inexpensive way to treat an unground bearing to resist rust is to cadmium plate the parts. A substitute plating in these days of critical cadmium shortage would be zinc plating or one of the chemical oxide treatments such as Parkerize, Pentrate, Bonderize, etc. If a more rust resistant bearing is required, brass or stainless steel can be used. Various end uses would dictate the choice of stainless steels. If an unhardened part will withstand the operating loads, an austenitic stainless such as type 303 would generally be preferred while if a heavy load is to be encountered it is usual to specify a martensitic stainless such as type 440C, which can be hardened.

Occasionally a bearing may be made with just certain parts made from a special material. For example, a bearing was desired on one occasion with just the outer part made from stainless steel. This bearing was to be used in a corrosive atmosphere. The stainless outer section prevented the bearing from rusting to the housing, making replacement easy.

During these days of defense effort, plus normal peacetime operations and the everpresent need to meet competition by producing better machines at minimum cost, unnecessary use of critical materials and parts should be avoided. Hence, it behooves the design engineer to become more and more conscious of the importance in effecting utmost economy without sacrifice of performance. Especially is this true of manufacturers caught in the "squeeze" between ceiling prices and the still rising costs of labor and materials. Accordingly, the unground bearing, already recognized by many design engineers as a practical economic answer to many bearing cost problems, can be utilized advantageously in many cases beyond the scope of present applications when its full potentialities are known.

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## They Say...

"To properly fit into industry it is necessary for the engineer to have, in addition to technical competence, schooling in human relationships and skill in organization and administration. These skills are acquired largely by experience and initiative. It is a process of self-education. I believe it is desirable that some part of our engineering curricula should include a certain amount of formal study of these subjects in order that our engineers may be better fitted to carry out the demands that will inevitably be made by industry"—CARL H. COTTER, *president, Merritt, Chapman and Scott.*

"Examine your organization and see if some of your trained engineers are doing work that can be assigned to supporting personnel. If the answer is affirmative, we urge you to rectify that situation promptly."—H. N. MULLER JR., *assistant vice president, Westinghouse Electric Corp.*

# Equivalent Number of Teeth for Bevel Gears

By C. J. Schorsch
*Proposal Engineer*
*United Engineering and Foundry Co.*
*Pittsburgh, Pa.*

BEFORE the bending stress in the teeth of bevel gears can be calculated, the equivalent or virtual number of teeth must be known. The equivalent number of teeth, rather than the actual number, governs selection of the appropriate form factor for use in the well-known Lewis formula. This data sheet presents a nomogram for the rapid determination of equivalent number of teeth for bevel gears with shaft angles ranging from 0 to 150 degrees and gearing ratios from 1 to 5.

The general equation for the equivalent number of teeth in all conventional types of straight-tooth bevel gears, *Fig.* 1, is (see Nomenclature)

$$N_{eP} = \frac{N_P}{\cos \alpha_P} = \frac{N_P}{\cos\left(\tan^{-1}\dfrac{\sin \Sigma}{\dfrac{N_G}{N_P} + \cos \Sigma}\right)} \quad \ldots\ldots\ldots\ldots (1)$$

$$N_{eG} = \frac{N_G}{\cos \alpha_G} = \frac{N_G}{\cos (\Sigma - \alpha_P)} \quad \ldots\ldots\ldots\ldots (2)$$

The nomogram of *Fig.* 2 is a two-step graphical solution of Equation 1, giving equivalent number of teeth of the pinion. In the first step, solution is given for

$$\alpha_P = \tan^{-1}\frac{\sin \Sigma}{\dfrac{N_G}{N_P} + \cos \Sigma}$$

The procedure is: Enter grid with $N_G/N_P$ value along top horizontal scale, descend vertically to curve of known $\Sigma$, proceed horizontally to vertical $\alpha_P$ scale.

In the second step, solution is given for

$$N_{eP} = \frac{N_P}{\cos \alpha_P}$$

The procedure is: Project line from $\alpha_P$, found in step 1, to known value of $N_P$ on right-hand vertical scale, and read $N_{eP}$ on central vertical scale.

Equivalent number of teeth for the gear may be found by partial use of *Fig.* 2. Since $\Sigma = \alpha_G + \alpha_P$, $\alpha_G$ is simply $\Sigma - \alpha_P$. Step 2 for *Fig.* 2 thus can be utilized to find $N_{eG}$. In this case, the bracketed labels hold for the three vertical scales. That is, a line joining known values of $[\alpha_G]$ and $[N_G]$ gives $[N_{eG}]$.

**Nomenclature**

| | |
|---|---|
| $D_G, D_P =$ | Pitch diameters of gear and pinion, inches |
| $N_{eG}, N_{eP} =$ | Equivalent numbers of teeth in gear and pinion |
| $N_G, N_P =$ | Real numbers of teeth in gear and pinion |
| $\alpha_G, \alpha_P =$ | Pitch cone angles of gear and pinion, deg |
| $\Sigma =$ | Shaft angle of bevel gears, deg |

If equivalent diameters of bevel gears are required, the foregoing equations and *Fig.* 2 can be easily adapted to this purpose by merely substituting $D$ for $N$, letting subscripts remain unchanged. Shifting of the decimal point on the adapted $N$ and $N_e$ scales may prove to be necessary or convenient.

When scale ranges are exceeded or greater accuracy than given by the chart is required, Equations 1 and 2 must be used for the calculation of equivalent numbers of teeth. These equations can be simplified for two of the five cases shown in *Fig.* 1: right-

# Data Sheet

angle bevel gears and crown gears.

For right-angle bevel gears, with $\Sigma = 90$ deg,

$$N_{eP} = \frac{N_P}{\cos \alpha_P} = \frac{N_P}{\cos\left(\tan^{-1}\frac{N_P}{N_G}\right)} \quad \ldots\ldots (3)$$

For crown gears, with $\alpha_G = 90$ deg,

$$N_{eP} = \frac{N_P}{\cos \alpha_P} = \frac{N_P}{\cos\left(\sin^{-1}\frac{N_P}{N_G}\right)} \quad \ldots\ldots (4)$$

Equation 2, of course, gives $N_{eG}$ for both cases.

As a convenient reference, form factors for the Lewis formula are given in TABLE 1. These factors are for use with diametral pitch; they should be divided by $\pi$ if calculations are based on circular pitch.

EXAMPLE 1: Find the equivalent number of teeth in the bevel gears of a speed reducer for the following data: Shaft angle $\Sigma = 70$ deg, $N_P = 54$ and $N_G = 70$. Step 1 in *Fig.* 2, with $N_G/N_P = 70/54 = 1.3$, gives $\alpha_G = 29.8$ deg and Step 2, $N_{eP} = 62$. For the gear, $\alpha_G = \Sigma - \alpha_P = 70 - 29.8 = 40.2$ deg. In *Fig.* 2, Step 2 with $[\alpha_G] = 40.2$ and $[N_G] = 70$ gives $[N_{eG}] = 92$.

**Table 1—Lewis Form Factors***

| Equivalent Number of Teeth | Involute System 14½ Deg | 20 Deg Full Depth | 20 Deg Stub |
|---|---|---|---|
| 12 | 0.210 | 0.245 | 0.311 |
| 13 | 0.220 | 0.261 | 0.324 |
| 14 | 0.226 | 0.276 | 0.339 |
| 15 | 0.236 | 0.289 | 0.348 |
| 16 | 0.242 | 0.295 | 0.361 |
| 17 | 0.251 | 0.302 | 0.367 |
| 18 | 0.261 | 0.308 | 0.377 |
| 19 | 0.273 | 0.314 | 0.386 |
| 20 | 0.283 | 0.320 | 0.393 |
| 21 | 0.289 | 0.327 | 0.399 |
| 22 | 0.292 | 0.330 | 0.405 |
| 24 | 0.298 | 0.336 | 0.415 |
| 26 | 0.307 | 0.346 | 0.424 |
| 28 | 0.314 | 0.352 | 0.430 |
| 30 | 0.320 | 0.358 | 0.437 |
| 34 | 0.327 | 0.371 | 0.446 |
| 38 | 0.336 | 0.383 | 0.456 |
| 43 | 0.346 | 0.396 | 0.462 |
| 50 | 0.352 | 0.408 | 0.474 |
| 60 | 0.358 | 0.421 | 0.484 |
| 75 | 0.364 | 0.434 | 0.496 |
| 100 | 0.371 | 0.446 | 0.506 |
| 150 | 0.377 | 0.459 | 0.518 |
| 300 | 0.383 | 0.471 | 0.534 |
| Rack | 0.390 | 0.484 | 0.550 |

* For use with diametral pitch.

EXAMPLE 2: *Fig.* 2 can also be used to find pitch cone angles of bevel gears during exploratory design work. Find the cone angle of a tentative bevel pair for shaft angle $\Sigma = 140$ deg and ratio $N_G/N_P = 1.75$. Entering the nomogram at $N_G/N_P = 1.75$, descending to $\Sigma = 140$, and reading from the left-hand vertical scale give $\alpha_P = 33$ deg. The gear cone angle is $\alpha_G = \Sigma - \alpha_P = 140 - 33 = 107$ deg. Hence, the tentative design dictates an internal bevel gear, which is difficult to manufacture. An acute-angle bevel pair can well be substituted. That is, an equivalent design for the intersecting shafts would be based on $\Sigma = 180 - 140 = 40$ deg.

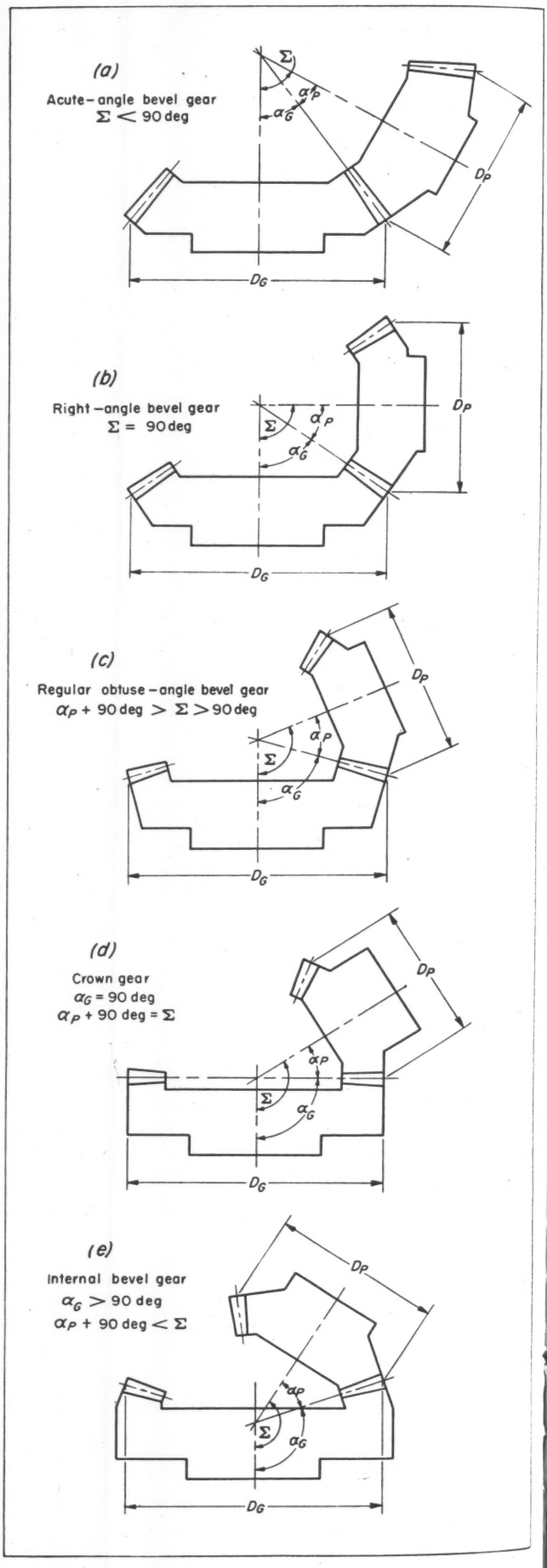



Fig. 1—Conventional types of bevel gears

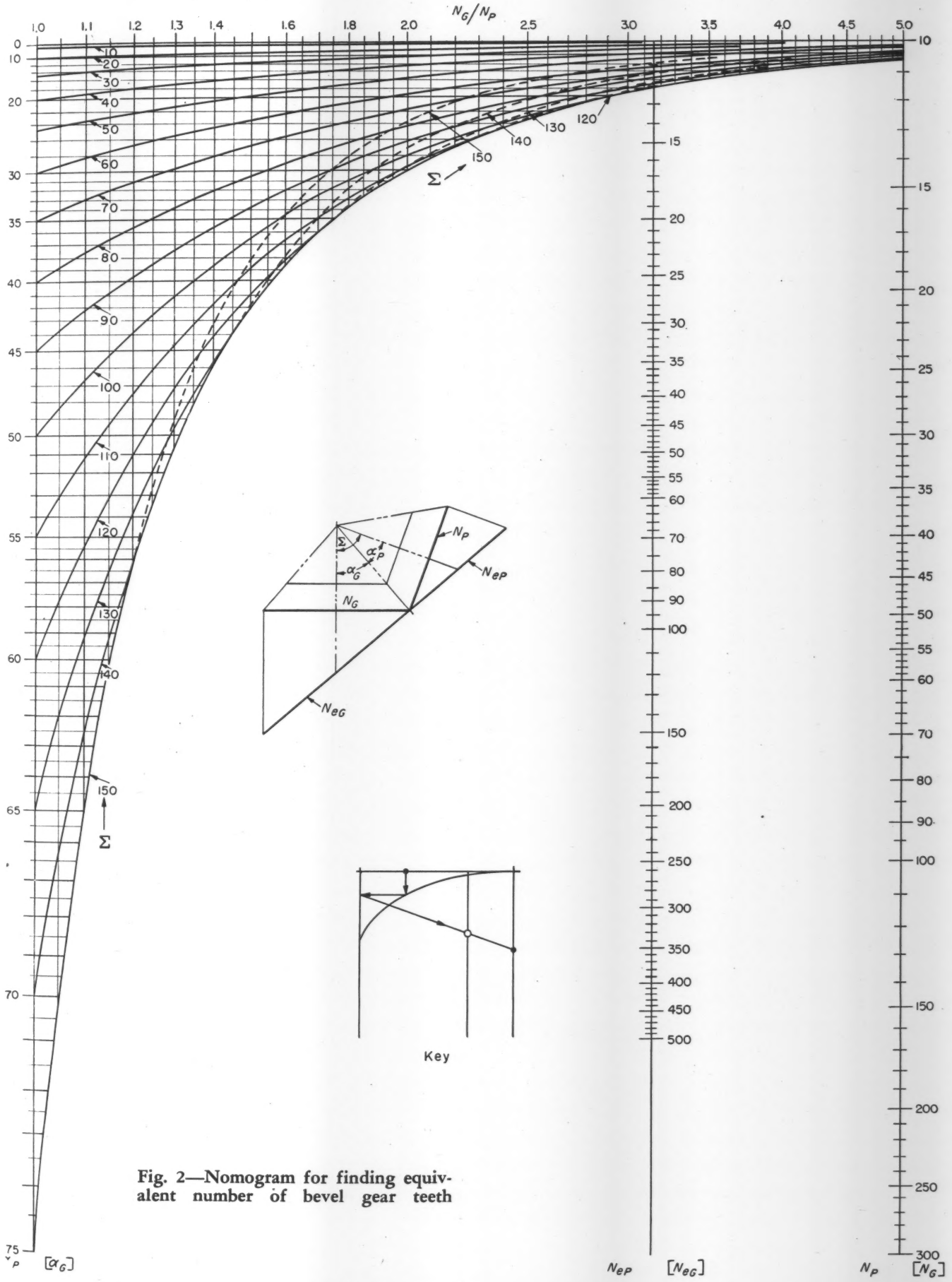



Fig. 2—Nomogram for finding equivalent number of bevel gear teeth

# Strength of Alloy Cast Irons

By H. A. Altorfer
*Nordstrom Valve Div.*
*Rockwell Mfg. Co.*
*Oakland, Calif.*

WITHIN the past decade, or slightly longer, cast iron has been developed from a relatively low grade material to one having high strength. Published figures on some alloy iron tensile strengths compare favorably with those for steel. However, the correct interpretation and application of these figures is very important.

Large pneumatic and hydraulic pressure cylinders, such as those used for pneumatic valve operation on gas pipe lines, often utilize a cast section to obtain the most production economy. Full scale tests on cylinders have shown that the "useful" strength of even the highest grade of cast iron is far from that of steel, although available figures on tensile strength would lead one to believe that some of the higher grade irons are superior. The following analysis of the limitations of cast steel and cast iron, although based on experimental results for cylindrical vessels, may be applied to pressure vessels of all shapes.

For brittle materials, such as cast iron, the elastic limit is very close to the ultimate strength of the material and, for practical purposes, it may be said that the ductility of ordinary cast iron is zero. *Fig.* 1 shows typical stress strain diagrams for Class 50 alloy cast irons. It is a well known fact that the physical properties of cast iron depend on the section thickness. The three curves on *Fig.* 1 show the stress-strain characteristics for three specimens taken from cast bars of various diameters. Both the ultimate strength and the stress-strain relationship are clearly shown, the latter indicating the declining modulus of elasticity with increasing load. The end points of the curves indicate the ultimate tensile strength of the test specimen. Strain was exceedingly small, *Fig.* 1, when the specimens broke.

In contrast, *Fig.* 2 shows a typical load-elongation diagram for a ductile steel. This specimen did not break until it had elongated by approximately 1/3 of its original length. A comparison between

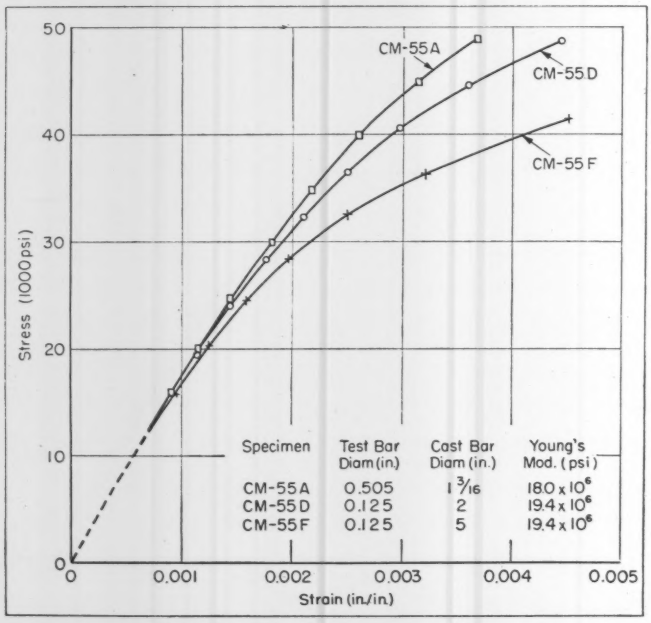
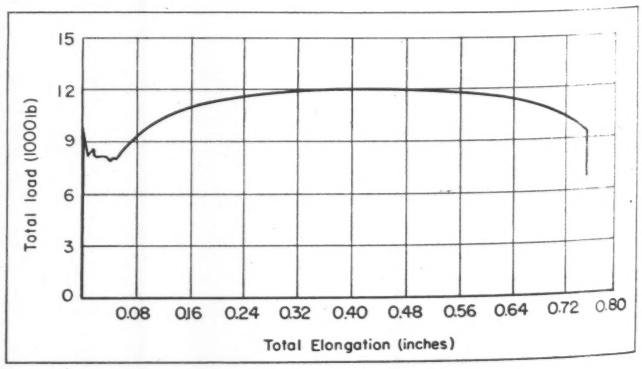



Fig. 1—Left—Stress-strain curves for three Class 50 alloy cast irons

Fig. 2—Below—Typical load-elongation curve for a ductile steel (0.505-in. dia. x 2-in. specimen)



the stress-strain characteristics of the ductile steel and the relatively brittle cast iron shows the significance of ductility.

Elastic deformation takes place under Hook's law and is expressed as

$$\epsilon = \alpha \sigma$$

where $\epsilon$ = extension per unit length, $\sigma$ = stress per unit area, $\alpha = 1/E$ a constant depending on the material, and $E$ = modulus of elasticity of the material. Hook's law is usually qualified by stating that it applies up to the proportional limit, a point beyond which the factor $\alpha$ would change. On the stress-strain diagram Hook's law applies over the straight portion of the elastic line. When referring to the stress-strain curves for Class 50 alloy cast irons, *Fig.* 1, it is interesting to note that this material has no distinct proportional limit and the modulus of elasticity, of which the tangent to the stress-strain curve is a measure, is constantly decreasing from its initial value.

For steel it has been found practical to figure that, for every 0.001-in. extension per inch of length, the resulting tensile stress would be 30,000 psi. This is obvious from Hook's law. On cast iron in the lower stress ranges the stress corresponding to 0.001-in. of extension per inch of length, ranges from roughly 12,000 psi for the lowest grade iron to 24,000 psi for iron of the highest obtainable grade.

The stress configuration through a cylinder wall of cast iron is shown in *Fig.* 3*a*. As soon as the tensile stress at the bore reaches the elastic limit, which may be considered equal to the ultimate tensile strength of the material, the brittle iron cylinder fails, fracture starting at the inner surface. In contrast, for the ductile steel, when the elastic limit at the bore is exceeded, yielding in the overstressed regions will take place up to the point in the wall where the elastic limit exists, as shown in *Fig.* 3*b*, and from that radius outward the tensile wall stress follows the stress configuration of *Fig.* 3*a*. The ductile steel has a limiting condition which occurs when the location of the stress corresponding to the elastic limit has moved to the outer wall. As indicated in *Fig.* 3*c*, the tensile stress through the wall will be approximately uniform and equal to the elastic limit of the material. For the ductile steel it is interesting to note that upon release of the internal pressure a residual stress will appear at the bore and extend through the wall, its magnitude depending upon the amount of yielding that occurred under pressure.

**Table 1—Pressure Vessel Test Results**

| Types of Material | Tensile Strength (psi) | Bursting Pressure (psi) | Calculated Stress (psi) |
|---|---|---|---|
| Class 40 Gray Iron .. | 44,700 | 7,200 | 23,700 |
| Alloy Gray Iron ..... | 71,900 | 8,250 | 27,200 |
| Cast Steel ..... | 72,200 | 16,200 | 44,200 |

Full scale tests were performed on several thick-wall pressure vessels of different materials. The results of these tests are shown in TABLE I for three different materials; a medium grade iron, a high grade iron, and cast steel. The bursting tests were carried to destruction, that is, Class 40 and special alloy gray iron to fracture, cast steel to such a degree of distortion the joint leakage prevented any increase in pressure. Tangential wall stress was calculated from the bursting pressure. It was deemed advisable to use two different methods of calculation for arriving at the critical bursting stress. The gray irons were assumed to be 100 per cent brittle and would, therefore, fail under the elastic laws corresponding to a stress configuration as shown in *Fig.* 3*a*, fracture taking place as soon as the stress at the cylinder bore reached the tensile strength of the material. The cast steel cylinder distorted, owing to the yielding capacity of the material and fracture did not take place. A reasonable assumption is that the tangential stresses became equalized across the cylinder wall and the wall stress became uniform and equal to the yield strength of the steel. The tangential wall stress thus calculated is given in TABLE I.

It is remarkable to note from these figures that the bursting stress (calculated stress) of the special alloy iron was not much greater than half of the so called bursting stress of the cast steel vessel although it showed practically the same tensile strength on the test bar. Remarkable too is the fact that the bursting stress of the Class 40 iron was found to be as much as 87 per cent of the stress at failure of the special alloy iron cylinder although its test bar showed only 62 per cent of the tensile strength of the latter. These test bars were machined from the

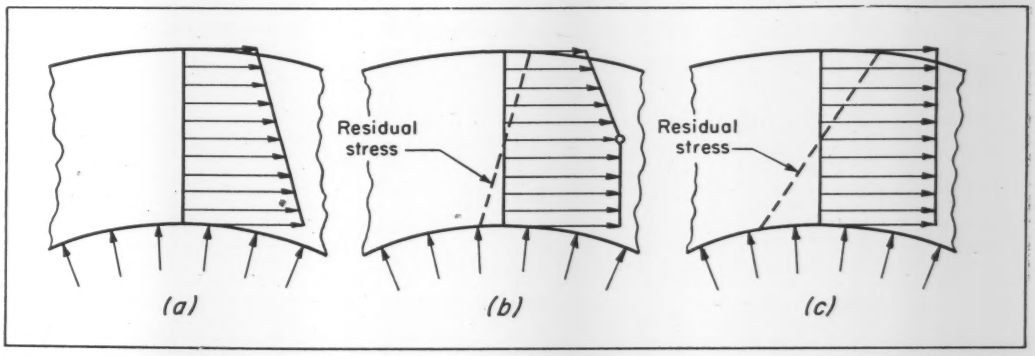



Fig. 3—Stress distribution through a cylinder wall for *a*, cast iron; *b*, ductile steel with partial yielding; *c*, ductile steel with complete yielding

pressure vessel casting itself.

An examination of the ruptured gray iron vessel revealed that the casting fractured through the bolt holes at the cover flanges. The conclusion may be reached that the fracture did actually start at these bolt holes and was the result of stress raisers created by the thread, and further, that the special alloy iron appears to be far more notch sensitive than the lower grade iron. For cylinders exposed to static pressure it is, therefore, questionable as to whether the high grade special alloy iron is economically justified. The situation seems to be similar to the fatigue phenomenon on ordinary and alloy steels wherein alloy steels are so notch sensitive that they have actually little more useful strength than ordinary carbon steel. Also, recent investigations have found no greater impact strength in notched specimens of nodular iron of high tensile strength than in similar specimens of grade 40 cast iron although there was a great difference in the test results obtained from unnotched samples.

Further refinement in the analysis of stress conditions at the threaded holes may contribute greatly to an understanding of the phenomenon that is taking place on iron cylinders, however, high grade irons, because of their high notch sensitivity, are not much better than the lower grade materials, at least under static conditions. It is obvious from the analysis that stress concentrations on cast steel are to a great extent neutralized due to the excellent ductility of the material.

In determining factors of safety to be used in the design of pressure vessels, the failure stress should be the basic criterion and a value of 5 may be considered reasonable for the inherently brittle cast iron while the value 4 appears to be practical for steel.

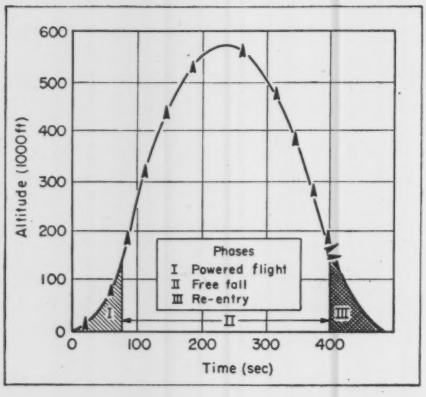
*From a paper entitled, "Failure Conditions in Ferrous Metal Cylinders," presented at the* 1951 *ASME Fall Conference in San Francisco.*

# Designing the Viking Rocket

By W. G. Purdy
*The Glenn L. Martin Co.*
*Baltimore, Md.*

MANY of the initial design problems and considerations presented by Viking were radically different from those that normally confront the aircraft designer. These problems stemmed largely from the unconventional nature of the rocket's flight, which as *Fig.* 1 shows, can be divided into three phases—powered flight, free fall, and re-entry. For the most part, the rocket is designed for the conditions obtaining during the first phase. It is during this short interval that the missile gathers the momentum necessary to carry it to peak altitude during the second phase. Since the rocket must enter the second phase on a stable vertical heading, these conditions must be maintained during the first phase also. The 20,000 lb of thrust applied by the power plant over this 1.25-minute period accelerate the vehicle to a velocity of over 5,000 fps. The rapid and large-scale changes in altitude and air loads produce operating conditions during the powered flight period which may be variable.

Fig. 1—Power, free fall and re-entry phases of a rocket during flight

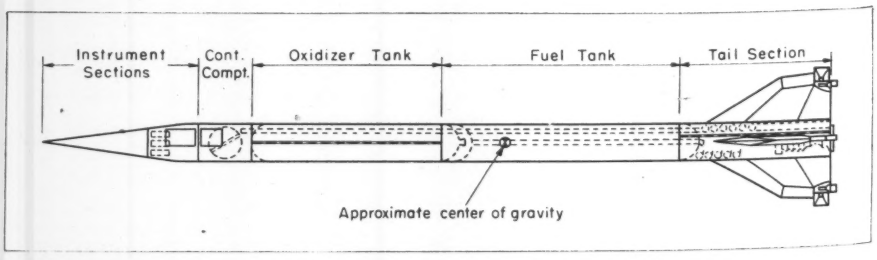



During the stillness of the second phase, the Viking spends about 5.5 minutes coasting to peak altitude and back to 130,000 ft. Although the rocket proper is almost dead, it is this phase that justifies the Viking's existence, since it is from this region that most of the upper air research data are desired. Aside from the instruments that make up the pay load, the only active part of the rocket is the coasting flight stabilization system that is required to trim out residual heading errors remaining at the end of powered flight.

The beginning of the third or re-entry phase is marked by the region where the atmosphere becomes dense enough to turn the rocket over so that it approaches the earth nose first. At this point, the Viking has completed its mission except for operations to im-

(*Continued on Page* 210)

Fig. 2—Schematic view of Viking rocket make-up



# NEW PARTS

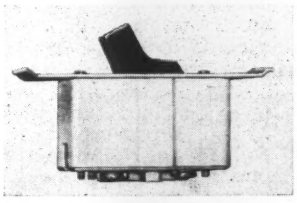
## AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 181

## DOUBLE-POLE SWITCH 1

### . . . withstands high appliance temperatures

*John I. Paulding Inc., New Bedford, Mass.*



Manufactured of heat-resistant materials this switch is claimed to be "foolproof" in electric appliance applications.

**Size:** $1\frac{13}{16}$ in. long, $1\frac{5}{16}$ in. wide, $1\frac{1}{4}$ in. high.

**Service:** Electric circuits at sustained temperatures to 450 F, intermittent to 600 F; arcing prevented by phenolic barrier; approved by Underwriters Laboratories.

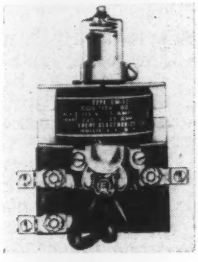
**Design:** Double-pole, snap-action; precision-molded electrical porcelain box; molded phenolic breaker bars; electrical porcelain barrier separating terminals; large-head screw terminals; special face-plates for mounting are available.

For more data circle MD 1, Page 181

## THREE-WIRE RELAY 2

### . . . with contacts hermetically sealed in glass

*Ebert Electronics Co., 185-09 Jamaica Ave., Hollis, Long Island, N. Y.*



Sealed construction allows safe operation under adverse atmospheric conditions.

**Designation:** EM-10.

**Size:** $3\frac{3}{8}$ in. wide, $4\frac{3}{8}$ in. high, $2\frac{1}{4}$ in. deep.

**Service:** Relay loads up to 35 amp at 115 v ac or 25 amp at 220 v dc; elimination of exposed arc permits safe use in explosive atmospheres.

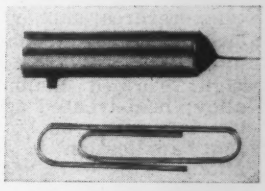
**Design:** Three-wire mercury plunger; when contact is made, input line connects to the two isolated circuits; tungsten contacts are hermetically sealed in vacuum or hydrogen-filled glass tubes.

For more data circle MD 2, Page 181

## MINIATURE THERMOSTAT 3

### . . . adjustable over wide range

*Thomas A. Edison Inc., Instrument Div., West Orange, N. J.*



Completely enclosed in metal, this thermostat is designed for long-time stability and accuracy.

**Size:** $1\frac{1}{4}$ in. long, $\frac{5}{16}$-in. diam.

**Service:** Temperature range, − 50 to + 350 F, adjustable ± 60 F from factory setting; contacts are rated 1 amp at 115 v ac or 0.5 amp at 115 v dc.

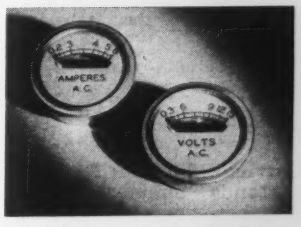
**Design:** Bimetal temperature element anchored by ceramic bushing for sustained stability; separate phosphor-bronze spring carries the moving contact, preventing bimetal from taking a set or becoming overstressed by extreme contact pressure.

For more data circle MD 3, Page 181

## ELECTRIC METERS 4

### . . . miniaturized for close mounting

*Sterling Mfg. Co., 9212 Detroit Ave., Cleveland, O.*




Formerly requiring a $2\frac{1}{32}$-in. opening, this unit has been reduced in size 40%.

**Size:** Mounting hole diam, $1\frac{5}{8}$ in.; back panel clearance, 1 in. from flange.

**Service:** Available in various ac or dc models for ranges of 1 to 50 v, 1 to 30 amp, 10 to 1000 milliamp; reading accuracy, 5% at any given point, 10% overall.

**Design:** Meters are mounted with 4 panel-mounting lugs and keyed-in mountings; dull black, wrinkle or nickel finish.

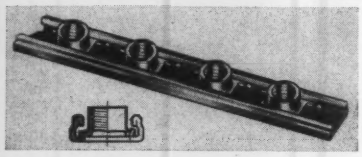
For more data circle MD 4, Page 181

# NEW PARTS

## GANG CHANNEL 5

### . . . for multiple-locknut installations

*Kaynar Mfg. Co. Inc., Engineering Dept. C-12, 820 E. 16th St., Los Angeles, Calif.*



Containing spring-steel locknuts as inserts, this gang channel is available in regular hole spacings or with special hole patterns.

**Designation:** Kaylock.

**Size:** 8-32 through ¼-28 screw-thread sizes.

**Service:** Lock-fastening service with multiple in-line anchor nuts; double vertical wall has high "pushout" resistance and rigidity, requiring fewer attachment rivets; close center to center spacing possible; high temperatures; anchor nuts, formed to elliptical shape, lock bolt over several threads by spring pressure; meet Army-Navy-Air Force specifications.

**Design:** Formed channel of 24-ST Alclad aluminum alloy; heat-treated spring-steel anchor nuts; assembly is narrow as standard AN-366 anchor nut, so that application is interchangeable with standard nuts.

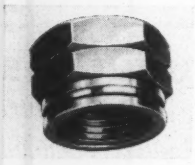
For more data circle MD 5, Page 181

## FREE-RUNNING LOCKNUT 6

### . . . spreads stress over number of threads

*Klincher Locknut Corp., 2153 Hillside Ave., Indianapolis, Ind.*

A grooved washer, pressed over a threaded section of the nut, compresses when tightened to lock the nut section radially on the bolt.



**Size:**

| Thread | Hex (in.) | Height (in.) | Thread | Hex (in.) | Height (in.) |
|---|---|---|---|---|---|
| 10-32 | 3/8 | 1/4 | 9/16-18 | 7/8 | 39/64 |
| 1/4-28 | 7/16 | 5/16 | 5/8-18 | 15/16 | 43/64 |
| 5/16-24 | 1/2 | 23/64 | 3/4-16 | 1 1/16 | 13/16 |
| 3/8-24 | 9/16 | 13/32 | 7/8-14 | 1 1/4 | 15/16 |
| 7/16-20 | 5/8 | 31/64 | 1-14 | 1 7/16 | 1 1/16 |
| 1/2-20 | 3/4 | 9/16 | | | |

**Service:** Thread locking on bolts and studs; withstands temperatures to 1600 F without seizing; stress concentration and torsional load, normally found in first 3 threads of nut and bolt, is spread to main body of the nut; high wrench-torques can be applied; reusable; weatherproof.

**Design:** Stainless steel nut has internally threaded barrel extending below main body, over which a grooved washer is press-fitted; when proper torque is applied, washer compresses, causing threaded nut barrel to lock radially on bolt; when threaded nut section picks up full load, it elongates slightly, permitting stress to move up into main nut body; other materials available.

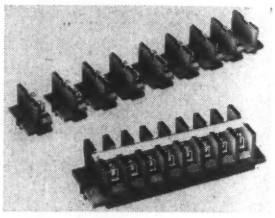
For more data circle MD 6, Page 181

## TERMINAL BLOCKS 7

### . . . built up with "add-on" units

*Wama Co., Industrial Bldg., Baltimore 2, Md.*

Simplified solderless connectors are now available with this company's interlocking terminal-block units.



**Designation:** Add-A-Point.

**Size:** 1 3/16 in. wide, 1½ in. high, 2⅛ in. deep, per unit; 11/16-in. between terminal points when assembled.

**Service:** Electric connections with rating up to 60 amp, 750 v; can be built up, unit by unit, to as many points as required, with No. 8 mounting screws at every 6 or 8 points; dielectric is tested to 17,000 v between adjacent points, 14,500 v between live parts and ground; dielectric strength of block material (60 cycles), 270 v per mil; temperatures to 300 F.

**Design:** One-piece point and barrier units are assembled to each other with short screws, with end-piece to finish assembly; marking strip then added to top; screw-type connectors, or solderless type for No. 14 to No. 6 wire; blocks molded of Bakelite plastic; available in colors for coding.

For more data circle MD 7, Page 181

## GLASS-FILLED PLASTIC 8

### . . . has high impact strength

*Plaskon Div., Libbey-Owens-Ford Glass Co., Toledo 6, Ohio*

Claimed to have higher impact strength than any other plastic material, this glass fiber and alkyd resin combination can be molded on conventional compression or transfer-molding presses.

**Designation:** Plaskon 440.

**Form:** Matted glass fibers with resin binder for molding.

**Service:** High impact strength of 12-24 ft lb per in. notch on Izod impact test; heat distortion, greater than 400 F; heat resistance, 300 F for long periods, 350 F for limited periods, 400 F for short periods; arc resistance (ASTM D495), 180+; flexural strength, 14 to 17,000 psi, with residual strength present after cracking due to reinforcing glass fibers; local failure due to high stress in many cases merely relieves the stress, leaving part serviceable; cracks do not spread under moderate stress; resists hydrocarbons, neutral organic solvents, mild acids; water absorption ranges from 0.25% (24 hr) to 1.4% (ultimate after 7 days); good machinability.

**Properties:** Dielectric constant—(60 cycles) 5.2-6.0, (1 mc) 4.0-4.5; dissipation factor—(60 cycles) 0.023-0.024, (1 mc) 0.019-0.020; coefficient thermal expansion, $10\times10^{-6}$ to $30\times10^{-6}$ in. per in. per deg F; thermal conductivity, $8\times10^{-4}$ to $12\times10^{-4}$ cal per sec per sq cm per deg C; heat capacity, 0.26 cal per gm deg C; modulus of elasticity, 1.6 to 2.0 million psi.

For more data circle MD 8, Page 181

JOHNSON BRONZE

**SLEEVE BEARING DATA**

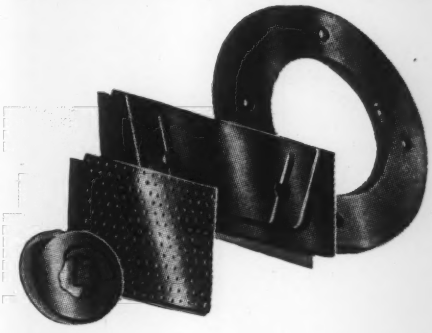
**Bearing TYPES**

JOHNSON BRONZE

**SLEEVE BEARING DATA**

# Sheet Metal Bearings-2

## Pre-Cast Bronze-on-Steel



WHILE this is a comparatively new type of bearing material, developed and patented by Johnson Bronze, millions of bearings and parts now in constant use provide definite proof of its excellent qualities.

Pre-Cast Bearing BRONZE-ON-STEEL is essentially a thin wall, laminated type of bearing that combines the bearing qualities of a high grade bronze alloy with the strength of steel. We start with a mixture of copper, tin and lead which is universally accepted as the best general purpose bearing bronze available. It combines, in the correct proportion, all the necessary elements to insure the utmost in bearing performance.

By casting this alloy in solid bronze bars we unite the metals chemically and form a definite copper-tin eutectic—with the lead trapped in the interstices. Thus the grain structure of the alloy—and the resulting bearings—is definitely established. Next, we reduce the bronze bar to a fine powder, about the same consistency as talcum. This powdered bronze is then treated in a hydrogen furnace to remove all oxides and then firmly bonded to copper coated strip steel. The process of manufacturing bearings from BRONZE-ON-STEEL, in strip form, is the same as for any other type of sheet metal bearing, being essentially a stamping and forming operation.

Bearings are made from this material in the same manner as bronze sheet metal bushings. The range of wall thickness is between .031" to .110". Lengths of bearings cannot exceed 4½". The smallest I.D. which can be formed is ⅜". Steel thickness for .052" wall bushings is .036"; for .070" wall it is .050" thick.

BRONZE-ON-STEEL is assembled by the same methods ordinarily used for bronze metal. It can be burnished with ordinary tools. It is also possible to bore and ream this material, but special carbide tipped tools are necessary. Diamond boring is sometimes recommended as a finishing operation.

### Chemical and Physical Properties of Bronze-on-Steel

| CHEMICAL ANALYSIS | Plain Bronze | Graphited Bronze |
|---|---|---|
| Copper | Balance | Balance |
| Tin | 8-11 | 8-11 |
| Lead | 8-11 | 8-11 |
| Graphite | none | 1.0 max. |

PHYSICAL PROPERTIES

| | (1) Rockwell Hardness E Scale | (2) Wear Rate | (3) Coefficient of Friction | (4) Resistance to Pounding | (5) Resistance to Pounding |
|---|---|---|---|---|---|
| Plain Bronze | 55 min. | 0.09 | 0.14 | 64 | 447 |
| Graphited | 55 min. | 0.02 | 0.13 | 57 | 255 |

1. Rockwell Hardness, E scale 100 Kg. Load—⅛" ball.
2. Wear Rate Loss of weight in grams—1 hour run, 1" I.D. bushing at 400 R.P.M.—.005" clearance—25 lb. per sq. in. pressure—no lubrication.
3. Coefficient of Friction—as determined on J. B. Machine. No lubrication.
4. Resistance to pounding—number of blows of 60 lb. hammer falling 2" to deform specimen .001"—1" x 1" x 1/16" specimen.
5. Same as (4) with deformation going to .005".

### Specifications

| | Standard Wall Thickness | For Shaft Diameters |
|---|---|---|
| 1. | .032—.035 | From 5/16" to 1½" Shaft |
| 2. | .042—.045 | From ⅜" to 1¾" Shaft |
| 3. | .062—.065 | From ⅝" to 2¾" Shaft |
| 4. | .092—.095 | Over 1¼" Shaft |

In order to obtain the best results from Pre-Cast Bearing BRONZE-ON-STEEL bushings and bearings, it is advisable to include the following information in your specifications:

1. SIZE of hole bushing is to be pressed into—rather than O.D. of bushings.
2. SIZE I.D. required after pressing into place. Manufacturers standard tolerance .002.
3. TYPE of body or housing bushing is pressed into.
4. SPECIAL FEATURES of bushing should be fully explained including their purpose.

## Thrust Washers

While BRONZE-ON-STEEL was developed primarily for Bushings and Bearings it also fills many other important industrial uses. It is ideal for applications requiring a flat bearing surface such as plates, washers, etc.

Some manufacturers prefer to purchase BRONZE-ON-STEEL in rolls and do their own stamping and forming. For such cases we can furnish it in rolls up to 400 feet in length. The maximum width of the strip cannot exceed 6½ inches.

*This bearing data sheet is but one of a series. You can get the complete set by writing to—*

Johnson Bronze

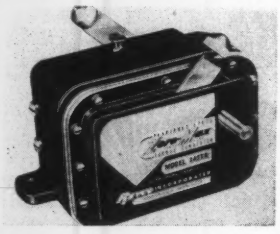
**SLEEVE BEARING HEADQUARTERS**
**525 S. MILL ST. • NEW CASTLE, PENNA.**

# NEW PARTS

## TORQUE CONVERTER 9

### . . . has variable speed in either direction

*Revco Inc., 2 E. Franklin Ave., Minneapolis 3, Minn.*



Speed control and reversing are independent, with reversal possible at any time.

**Designation:** Zero-Max 142XR.

**Size:** 6 in. long, 5¼ in. wide, 3½ in. high, excluding shafts, weight, 6 lb.

**Service:** Infinitely variable speed from 0 to ¼ of input speed in either direction; reversible at any time, with or without load on output shaft; reverse lever has neutral position where shaft is free and may be manually rotated in either direction; rated ¼-hp at 350 rpm with 1725 rpm motor input speed; load rating, 20 lb-in.

**Design:** Mechanical torque converter with separate speed and reverse control levers; levers operate in same plane.

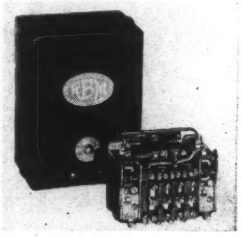
**Application:** Turntables, feeders, conveyors, laboratory and medical equipment.

For more data circle MD 9, Page 181

## MAGNETIC STARTER 11

### . . . built for accessibility from front

*R-B-M Div., Essex Wire Corp., Logansport, Ind.*



Stationary and movable contact assemblies may be replaced without disassembling the starter.

**Size:** NEMA size 0 to 1.

**Service:** For line-voltage ac magnetic starting; all parts accessible from front; all parts except stationary and movable contact assemblies are interchangeable between the two sizes.

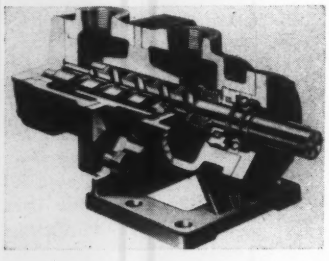
**Design:** Contact carrier and blocks of molded arc-resistant melamine; Ilsco solderless terminals for No. 6 wire are standard, screw terminals special; overload relay has palladium-silver contacts, enclosed heater element, expanding U-shaped bimetal with snap-action contact mechanism; trip-free manual reset is standard, or manual-automatic reset special at no additional cost; overload relays may be mounted separately.

For more data circle MD 11, Page 181

## SCREW PUMP 10

### . . . has only three moving parts

*De Laval Steam Turbine Co., Trenton 2, N. J.*



This model is about 40% lower in cost than other IMO models for similar pressures.

**Designation:** Imo A313B.

**Size:** Three models available, ranging from $12\frac{1}{16}$ to $17\frac{11}{16}$ in. long, 4½ to 6 in. wide, $5\frac{9}{16}$ to 7¾ in. high (pump only).

**Service:** Pumping 2.2 to 79.4 gpm (based on 150 SSU liquids at 250 psi) at continuous pressures up to 275 psi; intermittent pressures to 325 psi; quiet and pulsation-free; can be direct-connected to electric motors, turbines or high-speed drivers.

**Design:** Alloy-iron power rotor and pair of sealing or idler rollers are only working parts; replaceable alloy cast-iron rotor housing; discharge end-cover movable to 4 positions, allowing vertical or horizontal positioning of discharge port; mechanical shaft seal; prelubricated sealed ball bearings; available with riser pads to bring shaft in line with standard NEMA motor frames, or riser-pad and formed-steel base plate for motor mounting.

For more data circle MD 10, Page 181

## LAMINATING RESIN PLASTIC 12

### . . . retains high strength at high temperature

*U. S. Rubber Co., Naugatuck Chemical Div., New York 20, N. Y.*

Having high flexural strength at 500 F temperatures, this plastic, laminated with glass cloth, is expected to be used as a structural material in high-speed aircraft and guided missiles.

**Designation:** Vibrin X-1047.

**Form:** Clear straw-colored polyester resin powder for laminating with glass cloth.

**Service:** Structural panels and housings requiring high heat resistance; green flexural strength (laminated), 40,000 psi, modulus, 2.9; test strengths as follows:

| Test Time | 300 F Test: Flexural Strength (psi) | 300 F Test: Modulus ($\times 10^{-6}$) | 500 F Test: Flexural Strength (psi) | 500 F Test: Modulus ($\times 10^{-6}$) |
|---|---|---|---|---|
| **As Laminated** | | | | |
| Aged ½ hr | 30,000 | 2.5 | 24,000 | 2.0 |
| Aged 24 hr | 38,000 | 2.5 | 30,000 | 2.2 |
| Aged 192 hr | 45,000 | 2.2 | 13,000 | 1.5 |
| **Postcured (3 hr at 500 F)** | | | | |
| Aged ½ hr | 41,000 | 2.3 | 33,000 | 2.1 |
| Aged 24 hr | 44,000 | 2.4 | 33,000 | 2.3 |
| Aged 192 hr | 47,000 | 2.8 | 13,000 | 1.8 |

**Properties:** Polyester laminating resin with following properties (laminated with 181-114 glass cloth):

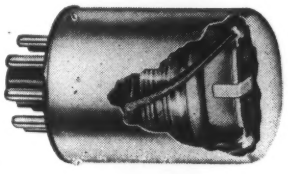
| | Green | Postcured (3 hr at 500 F) |
|---|---|---|
| Dielectric constant | 4.22 | ..... |
| Dielectric constant (wet) | 5.24 | ..... |
| Compressive strength | 29,000 psi | ..... |
| Tensile strength (at 25 C) | 28,700 psi | 30,700 psi |
| Notched Izod impact (25 C) | 20 ft lb | 12.5 ft lb |
| Rockwell hardness (25 C) | L-123, M-120 | L-122, M-119 |
| Water absorption (24 hr at 25 C) | +1.2% gain | +1.9% gain |

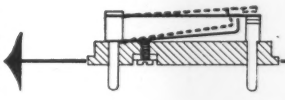
For more data circle MD 12, Page 181

*for fast response*
*close control*
*clean make and break*

# Stevens Type C Thermostats

- APPLIANCES
- ELECTRONIC APPLICATIONS
- CRYSTAL OVENS
- OSCILLATORS
- RADAR
- COMPUTERS





HERMETICALLY SEALED

STANDARD

● Stevens Type C* thermostats, compactly designed for equipment requiring a high degree of temperature stability, feature an electrically independent bimetal that responds only to heat from controlled device. Contacts open only when bimetal overcomes spring pressure and friction of bimetal strip against contact spring surface—*for a clean, positive break.*

Supplied with virtually any type terminal in standard or hermetically sealed styles, Stevens Type C thermostats *open or close* the circuit upon any predetermined temperature rise from—75° to 600°F.

Get faster response, closer temperature control. Specify Stevens Type C thermostats in your product —*for better performance and longer life.* A-3967

*PATENT APPLIED FOR

**STEVENS**

**manufacturing company, inc.**

MANSFIELD, OHIO

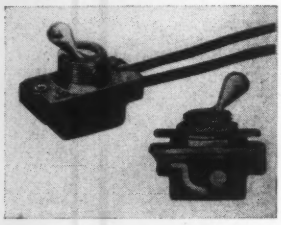
*Tiny Temp crystal oven courtesy of James Knights Co., Sandwich, Ill.*

# NEW PARTS AND MATERIALS

## TOGGLE SWITCH 13

### . . . easily adaptable to tools and appliances

*Slater Electric & Mfg. Co., 56th St. & 37th Ave., Woodside, N. Y.*



Claimed to be exceptionally versatile in application, this switch is available in a variety of mounting-sleeve lengths and terminals.

**Designation:** 170, 170-WL, 170-ST.

**Size:** 1¼ in. long, ½-in. wide, ½-in. deep; mounting-sleeve length, ¼ to $\frac{15}{16}$-in.

**Service:** Rating, 6 amp at 125 v, 3 amp at 250 v.

**Design:** Single-pole, single-throw toggle or momentary-contact; 170 has solder-lug terminals; 170-WL has wire leads; 170-ST has screw terminals; ball or bat-type handle in variety of lengths.

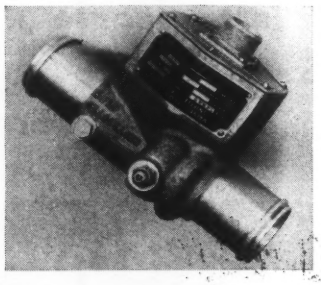
**Application:** Saws, drills, vacuum cleaners, fans, small heaters, hair dryers, mixers.

For more data circle MD 13, Page 181

## FLOW-CHECK VALVES 15

### . . . for fuel-tank purging systems

*Pacific Airmotive Corp., 2940 N. Hollywood Way, Burbank, Calif.*



Low-temperature and icing conditions are met satisfactorily by built-in heating elements.

**Size:** 1½ or 3 in. pipe size.

**Service:** Fuel purging operations; flow of air permitted in both directions—with outflow from tank at predetermined restricted setting and nearly unrestricted inflow to satisfy conditions of vacuum relief; 1½ in. size for 1 to 6 lb per min; 3 in. size for 2 to 12 lb per min; power, 24 v dc.

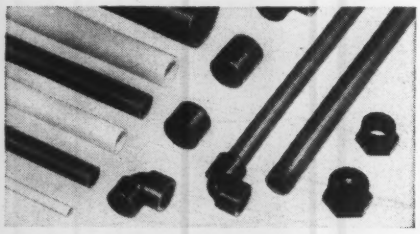
**Design:** Flow check, sniffle type; built-in heating elements and overheat thermostats.

For more data circle MD 15, Page 181

## PLASTIC PIPE 14

### . . . resists all types of chemical attack

*Munray Products Inc., 12400 Crossburn Ave., Cleveland 11, O.*



The first to be produced in this country by continuous extrusion methods, this polyvinyl chloride pipe is both hard and tough.

**Designation:** Polydur 162.

**Size:** OD to 2 in.; 10 or 25 ft lengths.

**Service:** Conducting acids, alkalies, salts, oxidizing agents, oils, greases, alcohols, gasoline and carbon tetrachloride at temperatures below 170 F; can be machined, welded, threaded or formed by heating to above 250 F; tensile strength, 5500-6050 psi; elongation, 30-80; Rockwell hardness, 106-107; specific gravity, 1.56; impact, 0.75 ft-lb per in. notch (room temp), 0.62 ft-lb per in. notch (—20 C); heat distortion, 79.4 C; 0.01-in. deflection at 264 psi and 175 F; good dielectric properties; self-extinguishing.

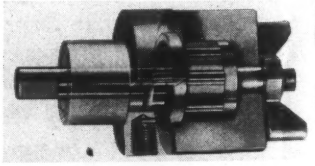
**Design:** Heavy wall rigid pipe with plain or flanged ends.

For more data circle MD 14, Page 181

## ROLLING-VANE PUMP 16

### . . . cylindrical in shape for integral mounting

*Milwaukee Hydropower Inc., 3447 N. 35th St., Milwaukee 16, Wis.*



Vanes are replaced by rollers to minimize friction and increase pump life.

**Designation:** Magna-Mite, types A, B or C.

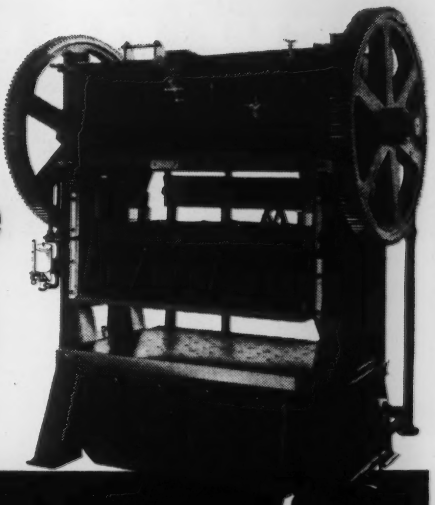
**Size:** 6 in. long, 2¾ in. diam; ¼-in. pipe thread.

**Service:** Pumping light-viscosity fluids with capacity from ¼ to 1½ gpm; rated at 1750 rpm—can be used from 300 to 3600 rpm; use of rollers increases pump life; type A, constant displacement; type B, adjustable displacement; type C, variable and reversible displacement.

**Design:** Positive-displacement; cylindrical shape and close-tolerance machining permit integral mounting; action of rollers against inner wall of pressure chamber induces formation of an oil wedge for lubrication; discharge volume on type B is adjustable with thumb lever; lever on type C controls pump to vary the volume, reverse or stop the flow, with motor and pump operating continuously; can be supplied with circular O-ring groove machined around ports for push-in insertion of pump into bored hole with matching inlet and outlet passages.

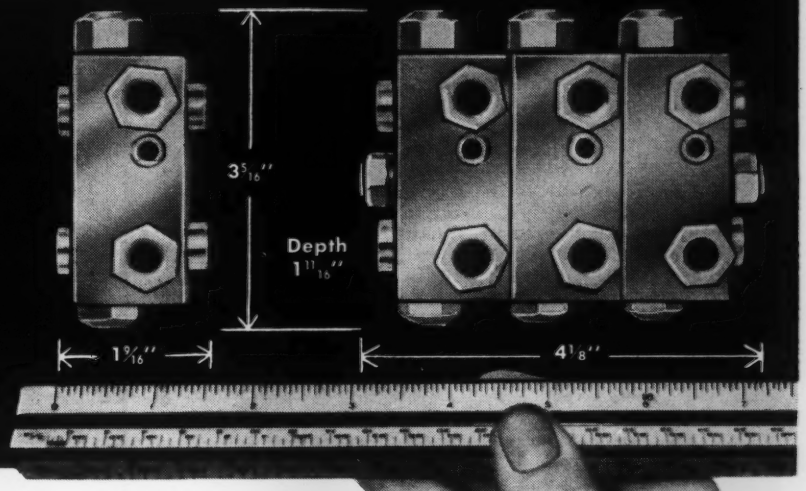
For more data circle MD 16, Page 181

# To help you...
# design more production time into the heaviest machines



## ALEMITE
## Accumeter VALVES

Valve illustrations one-half actual size




**Specially designed** for tough-job lubrication . . . to enable you to *design in* greater production output on the largest, heaviest machines! Alemite's Type II Accumeter System extends the protection of automatic *mechanized* lubrication to mines, steel mills, processing plants everywhere. Gives you a *fully enclosed* system that can be used indoors or outdoors, can be painted or treated with anti-corrosives, and will handle every type of oil or grease that can be pumped—from fluid oils to heavy non-fibrous greases.

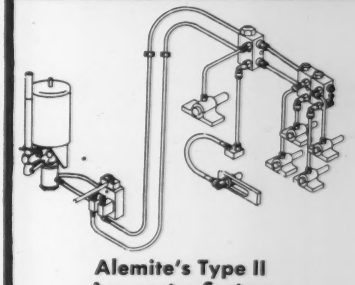
**The Alemite Type II** Accumeter Automatic Lubrication System consists of a lubricant pump, a distribution system of tubing, and *force-feed* valves mounted on or near individual bearings.

**Automatically,** from one central point, it safely, surely lubricates all the bearings on a machine—while production continues. Increases output by eliminating shut down for lubrication! Ends the risk of lubrication errors or neglect by your clients. Adds years to the life of the machine!

**Unlike other systems,** the valves on the Alemite Type II can be quickly serviced *without breaking the lines.* The valves have only three movable parts. Easily adjusted —adjusting pin cannot be knocked off. Nor is there ever the danger of scoring lap-fit metal.

**No other method** has equaled Alemite's Accumeter Systems for sustained accuracy in metering oil or grease to bearings. Tests show *no variation* in the amount of lubricant discharged to bearings . . . even after 73,312 lubrication cycles, equal to 122 years of twice-a-day service! Moreover, Alemite Accumeter Automatic Lubrication is not just "one-shot" lubrication. It is *continuous* between cycles. That's because Alemite's exclusive "accumulating" feature *prolongs* the discharge of lubricant to bearings.

**To meet your full range** of requirements, there are three different Alemite Accumeter Automatic Lubrication systems. Versatile in application, they are adaptable to machines of every type and size. Write now for Form 22-189, a free 16 page brochure giving full data. And for specific application recommendations, include description of machines you are now working on. Alemite, Dept. R-32, 1850 Diversey Parkway, Chicago 14, Illinois.



**Alemite's Type II Accumeter System**

Meters oil or grease to rotary, oscillating, stationary—plain or anti-friction bearings. Furnished in 4 capacities from .050 to .500 cu. in. All are adjustable. Single valves as well as manifolds of 2, 3, 4, and 5 are available. System handles up to 600 bearings. Manual or automatic operation.

# ALEMITE

REG U S PAT OFF

A PRODUCT OF SW STEWART WARNER

**ACCUMETER AUTOMATIC LUBRICATION**
**1850 Diversey Parkway, Chicago 14, Illinois**

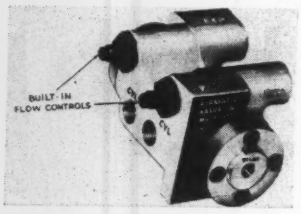
# NEW PARTS AND MATERIALS

## CYLINDER CONTROL VALVE 17

### . . . automatic controls piston retraction

*Airmatic Valve Inc., 1643 E. 40th St., Cleveland, O.*

Used with two auxiliary bleeder valves and a sequence valve, this valve provides automatic, semiautomatic and sequence operation of an air cylinder, also remote-control paneling.




**Designation:** MV-4-375.

**Size:** ¼, ⅜, ½, ¾-in. pipe size.

**Service:** Automatic or semiautomatic cylinder-control operation with air; also for oil or water; pressure to 150 psi; may be used with 2-way, normally-closed foot-operated, hand-operated, ac or dc solenoid-operated pilot control valve; eliminates insufficient pressure or excessive dwell in large-bore air cylinders of 6-in. diam or more.

**Design:** 4-way; momentary operation of a control bleeder valve operates master-valve spool, causing piston to advance; when piston reaches end of stroke, increased pressure opens a sequence valve (adjustable for pressure) causing a normally-closed pilot-operated bleeder valve to open; this action causes master valve spool in 4-way valve to shift and return piston to starting position; built-in flow controls; self-compensating for wear; noncorrosive.

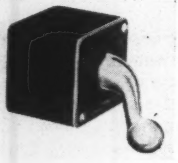
For more data circle MD 17, Page 181

## REVERSING SWITCH 18

### . . . with variety of mounting arrangements

*Allen-Bradley Co., Milwaukee 4, Wis.*

This small, simple switch is for machines and equipment requiring an economical across-the-line starter.



**Designation:** Bulletin 350, style A, A1, A2, A3.

**Size:** NEMA sizes 0 and 00.

**Service:** Across-the-line starting with maximum horsepower ratings as follows;

| Size | —Single Phase— | | ——2 or 3 Phase—— | | | ——DC—— | |
|---|---|---|---|---|---|---|---|
| | (110 v) | (220 v) | (110 v) | (220 v) | (440-500 v) | (115 v) | (230 v) |
| 0 | ¾ | ¾ | ¾ | ¾ | ¾ | ½ | ½ |
| 00 | 1 | 1½ | 1½ | 2 | 2 | ¼ | ¼ |

**Design:** Three-pole, double-throw; Bakelite housing contains 8 fixed contacts, moving contact assembly, ball lever handle and cover-plate assembly; handle operates cam which operates moving contact carrier; when movable and stationary contacts are lined up, a depression in the cam allows cam and contact carrier to move axially by spring pressure, bridging stationary contacts; style A—maintained contact; A1—spring return from reverse and forward positions; A2—return from reverse; A3—return from forward; available for cavity, angle, or junction-box mounting.

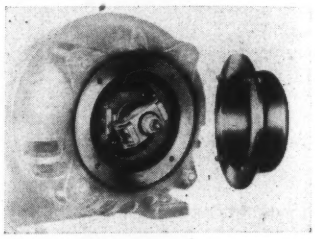
For more data circle MD 18, Page 181

## CAPACITOR-START MOTORS 19

### . . . have internally mounted condensers

*Hoover Co., Kingston-Conley Div., 68 Brook Ave., North Plainfield, N. J.*

In addition to improving appearance, the elimination of external condensers solves height problems where mounting space is critical.



**Designation:** KB.

**Size and Service:** For 115/230 v, 60 cycle ac current, except 3 hp size for 230 v only;

| Rating (hp) | Speed (rpm) | Frame Size (NEMA) | Rating (hp) | Speed (rpm) | Frame Size (NEMA) |
|---|---|---|---|---|---|
| ¾ | 1140 | 204 | 2 | 1725 | 224 |
| 1 | 1725 | 203 | 2 | 3450 | 204 |
| 1½ | 1725 | 204 | 3 | 3450 | 224 |
| 1½ | 3450 | 203 | | | |

**Design:** Capacitor-start, with condensers housed within mounting base; centrifugal starting switch mounted in external dustproof chamber; foreign matter cannot lodge between contact points; heavy-duty ball bearings.

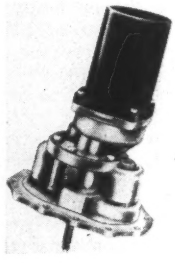
For more data circle MD 19, Page 181

## WATER-INJECTION PUMPS 20

### . . . supply antidetonant mixtures to engines

*Lear Inc., Romec Div., Elyria, O.*

Vertically mounted for immersion in antidetonant solution, the pump has all connections and adjustments accessible from outside the tank.



**Designation:** RG-8825.

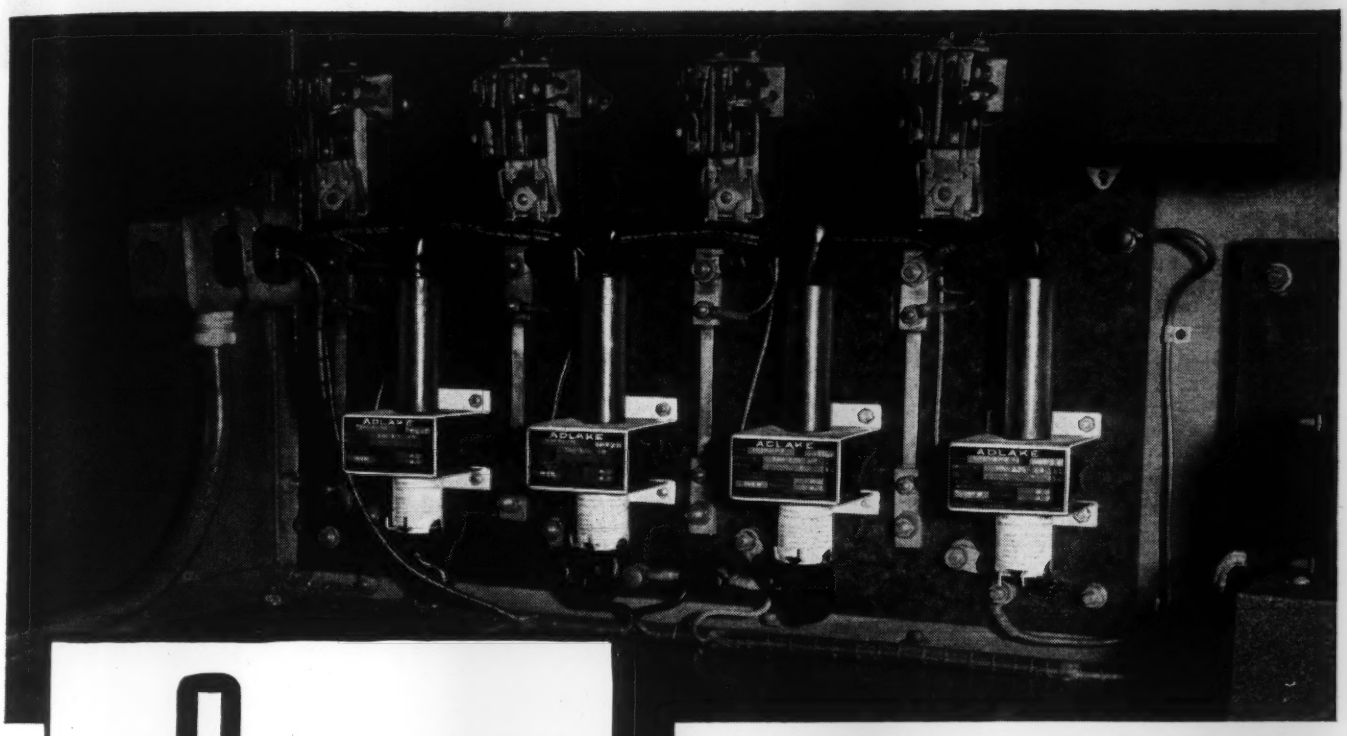
**Size:** 10$\frac{3}{32}$ in. high, 4⅞ in. wide; weight, 8.5 lb.

**Service:** Supplying water-alcohol mixtures vaporized in combustion chambers as antidetonants; galvanic corrosion eliminated by insulating pump and other metallic parts; supplies 160 gph at 25 psi; pressure is adjustable from 20 to 45 psi; motor is rated 1/5 hp, requiring 9.2 amp at 27 v dc; radio interference held below 50 mv by filter.

**Design:** Rotary 4-blade positive-displacement pump with air bypass pumps liquids only; diaphragm shaft seal on pump; O-ring over gear shaft prevents liquid from entering reduction gears and motor; flush mounting flange fits standard AN-4135 oval tank fitting; explosionproof motor cover; adjustable diaphragm relief valve; castings are anodized aluminum alloy; Monel pump liner and rotor; Graphitar bearings and blades, which permit low-friction running on Monel parts.

For more data circle MD 20, Page 181

**ADLAKE RELAYS AT WORK**—One of a series of advertisements on specific ADLAKE applications.



These No. 1040 type normally open ADLAKE heavy-duty relays are used in Ray-O-Vac's dry cell testing circuit. Contact resistance is very low, and the entire test loop cannot exceed .01 ohm, and must not vary.

# 8 years

## ON THE JOB FOR RAY-O-VAC

with no maintenance required!

# Adlake

## MERCURY RELAYS

**Many of the ADLAKE Relays** used by the Ray-O-Vac Company, Madison, Wisconsin, have functioned 62 times a minute for between five and eight years—and during that time have needed no maintenance whatever!

**The same engineering skill** that has given Ray-O-Vac this dependable, trouble-free performance is available for your relay problems. ADLAKE engineers are ready to work with you on any question of relay design and application. If you don't find the relay you need in the ADLAKE relay catalog, it will be custom-built for you.

**Find out for yourself** how ADLAKE Mercury relays will assure dependability and cut costs in your business. Write today for your free copy of the illustrated ADLAKE Relay Catalog—no obligation, of course. The Adams & Westlake Company, 1123 N. Michigan, Elkhart, Indiana.

**EVERY ADLAKE RELAY GIVES YOU THESE "PLUS" FEATURES:**

**Hermetically Sealed . . .**
dust, dirt, moisture, oxidation and temperature changes can't interfere with operation.

**Silent and Chatterless**

**Requires No Maintenance**

**Absolutely Safe**

**Mercury-To-Mercury Contact . . .**
prevents burning, pitting and sticking.

Adlake TRADE MARK

**THE Adams & Westlake COMPANY**

**Established 1857 • ELKHART, INDIANA • New York • Chicago • Manufacturers of ADLAKE Hermetically Sealed Relays**

# NEW PARTS

## METAL-CLAD PLASTICS 21

### . . . for printed electric circuits

*Richardson Co., 2765 Lake St., Melrose Park, Ill.*

Metal foil is bonded to the laminate under heat and pressure, giving high bond strength, but retaining good electric insulating properties of the plastic base.

**Designation:** Insurok T-831, -837, -845, -842.

**Size:** 36-in. x 42 in.; thickness, $\frac{1}{32}$ to $\frac{5}{32}$-in., inclusive; foil thickness, 1½ or 3 mils.

**Service:** As electric circuits after printing and etching; can be punched, sawed, drilled or otherwise machined; high bond strength.

**Design:** T-831 has copper surface bonded to Richardson T-725 laminated phenolic core; T-837, copper with T-812 core; T-845, aluminum with T-725 core; T-842, aluminum on T-812 core; metal covering on one or both sides; several special combinations are available.

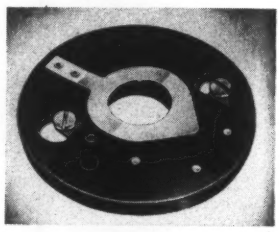
For more data circle MD 21, Page 181

## STARTING SWITCH 23

### . . . for fractional-horsepower motors

*Acro Mfg. Co., 2040 E. Main St., Columbus, O.*

Snap-action design of the switching mechanism permits positive control at the changeover point.



**Size:** To specifications; unit shown has 2.80-in. diam, 0.50-in. thickness.

**Service:** Controlling starting-winding operation; dirt or foreign matter cannot become lodged between exposed contacts.

**Design:** Totally enclosed, snap-action; housing is black thermosetting plastic; design to suit installation requirements; unit shown is designed to mount around motor shaft and is directly operated by a centrifugal unit.

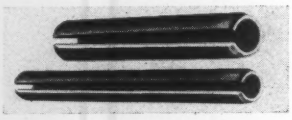
For more data circle MD 23, Page 181

## PIN FASTENER 22

### . . . expands to lock in tapered holes

*Self Lock Fastener Corp., 259 Stephens St., Belleville 9, N. J.*

Only normal production tolerances on straight drilled holes are required.



**Designation:** Sel-Lok.

**Size:** Standard and light-duty as follows; 0.062-in. diam, 0.250 through 0.750-in. lengths; 0.078 and 0.094-in. diam, 0.250 through 1.5 in. lengths; 0.125-in. diam, 0.375 through 2 in. lengths; 0.156 and 0.187-in. diam, 0.5 through 2.5 in. lengths; 0.250-in. diam, 0.625 through 3.5 in. lengths; heavy-duty, special.

**Service:** Lock fastening under shock and vibration conditions; can replace tapered pins; require only commercially drilled straight hole; may be inserted by hand or automatic machines; standard-duty has shear strength equal to solid pin of same diam; light-duty is for fastening unlike materials; heavy-duty has higher shear strength than solid pin of same diam.

**Design:** Tubular slotted dowel pin, of carbon or type 420 stainless steel; blue-black oiled finish on carbon steel, bright gray on corrosion resistant; hardness—carbon steel, Rockwell 46-53C—stainless, Rockwell 43-52C; chamfered on both ends; special materials—copper alloys, aluminum alloys, nonheat-treatable stainless steels; special finishes—cadmium or zinc plate, with or without postplate treatments.

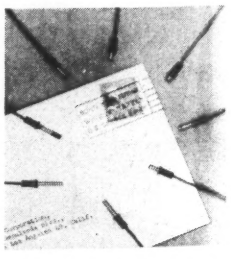
For more data circle MD 22, Page 181

## MINIATURE SLIPRINGS 24

### . . . have high arc resistance in limited space

*Naer Corp., 631 S. Sepulveda Blvd., West Los Angeles 49, Calif.*

Molded in plastic with high dielectric strength, these slip-rings are claimed to have minimum rotating friction and maximum heat resistance.



**Size:** 0.044 to 3 in. diam; ring width, 0.015 to 0.060-in.; barrier width, 0.015 to 0.040-in.; special sizes available.

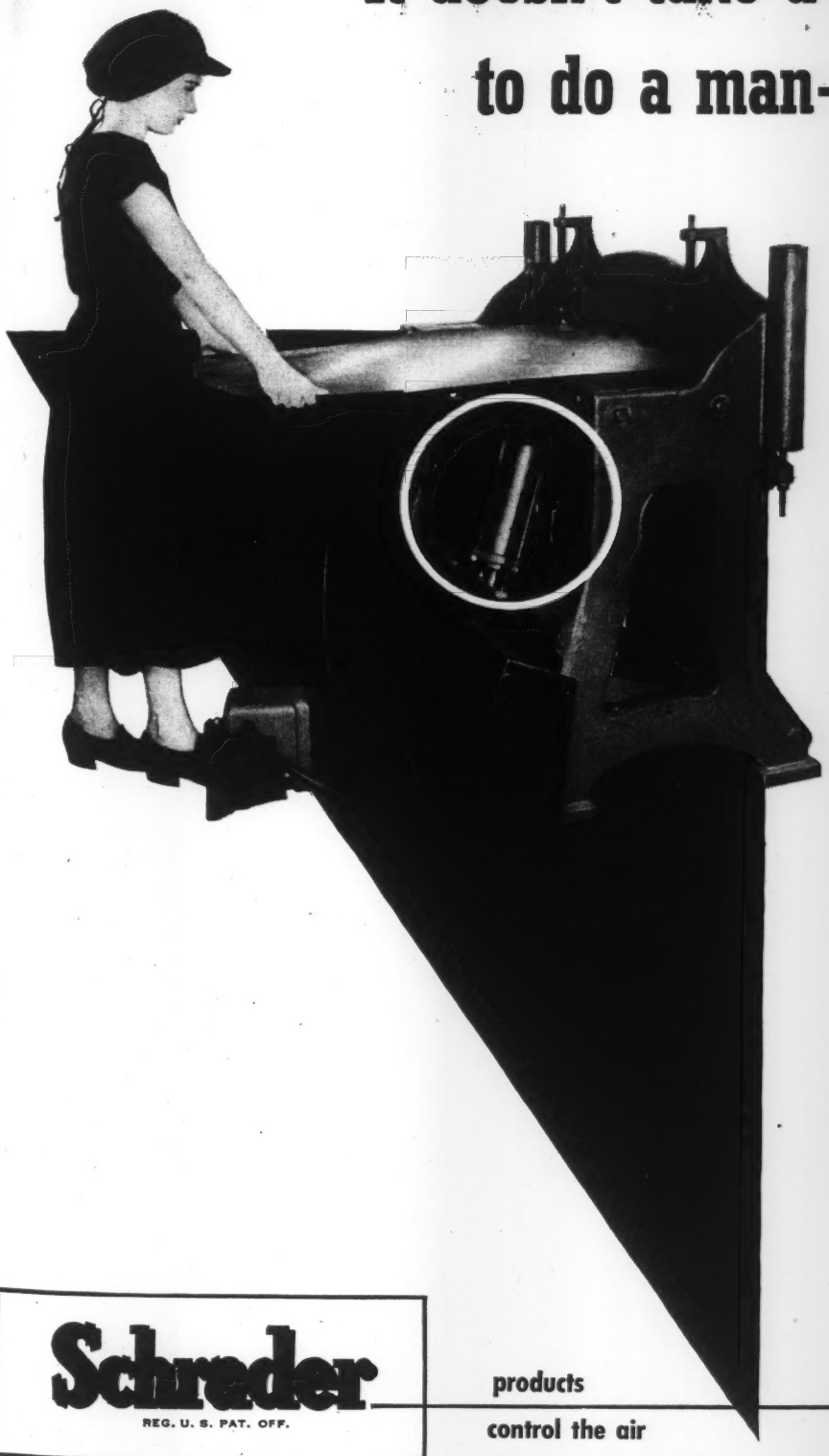
**Service:** Electric circuits in rotating parts at temperatures to 225 F; dielectric strength tested with 1000 v ac hipot test between circuits; low friction; high arc resistance at high altitudes; lead-in wires are flexible, abrasion and shock-resistant, have insulation with good dielectric strength.

**Design:** Silver, gold or platinum rings; body molded from plastic compound with 4500-5000 psi tensile strength, 6000-6500 psi flexural strength, 27.0 Rockwell hardness (M scale).

**Application:** Servomechanisms, guided missiles, gyros, selsyns, motors, synchro generators and transformers.

For more data circle MD 24, Page 181

# It doesn't take a heavyweight to do a man-sized job



Before these shears were shifted to air operation the entire weight of a man was required on the foot treadle to cut the sheet metal.

All this is changed now. A light touch of the girl's foot on the pedal puts all the power of the Schrader Air Cylinder to work, sending the knife-edge through the metal.

This is just one example of how air cylinders can speed up production and reduce fatigue . . . one of many hundred applications of Schrader cylinders and valves. It will pay you to design your controls around Schrader air cylinders and valves.

To find out how Schrader air control products can be put to work . . . to boost production . . . lessen operator fatigue . . . increase safety . . . send us a letter outlining your particular requirements, your idea or fill out the coupon below.

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**products control the air**

**Mail This Coupon Today**

Air Cylinders • Operating Valves • Press & Shear Controls • Air Ejection Sets • Blow Guns • Air Line Couplers • Air Hose & Fittings • Hose Reels • Pressure Regulators & Oilers • Air Strainers • Hydraulic Gauges • Uniflare Tube Fittings

**A. SCHRADER'S SON**
*Division of Scovill Manufacturing Company, Incorporated*
468 Vanderbilt Avenue, Brooklyn 17, N. Y., Dept. P-3

I am interested in more information on.....

Name_____ Title_____

Company_____

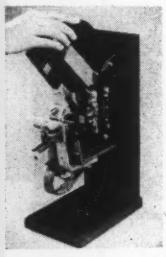
Address_____

# NEW PARTS AND MATERIALS

## DC CONTACTOR 25

### . . . for heavy-duty applications

*Westinghouse Electric Corp., Box* 2099, *Pittsburgh* 30, *Pa.*



Featuring extreme accessibility, these contactors are easily mounted, with alignment independent of the accuracy of panel drilling.

**Designation:** Type M.

**Size:** NEMA sizes from 25 to 2500 amp.

**Service:** Control of heavy-duty dc motors; knife-edge bearings are self-cleaning and not affected by dust; new arc-box design provides faster arc interruption, maintains correct alignment with the moving armature.

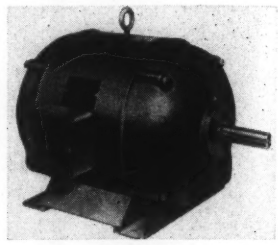
**Design:** Unit construction, completely accessible from front; alignment independent of panel drilling; knife-edge bearing fulcrum of hardened steel; interlocks mount directly on contactor frame, are unit-mounted on over 100-amp sizes; copper contacts, silver plated; stationary and moving contacts interchangeable on sizes over 100-amp; glass insulation on blowout coil assembly.

For more data circle MD 25, Page 181

## LARGE-SIZE MOTORS 27

### . . . designed for all-weather operation

*Robbins & Myers Inc., Springfield* 99, *O.*



Four motors have been added to this company's standard line, increasing maximum ratings to 125 hp.

**Size:** NEMA frame sizes 444, 445, 504 and 505.

**Service:** Rated at 60, 75, 100, 125 hp, respectively; resist moisture and corrosion; end-to-end ventilation eliminates converging air currents that deposit dust.

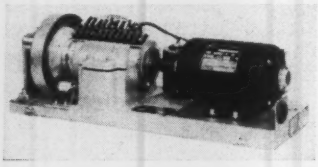
**Design:** Steel parts have baked-on, rust-resisting coating; rotor assembly treated with rust inhibitor; cast-iron end bells and terminal box are coated with zinc chromate; power leads sealed with non-hardening compound; prelubricated ball bearings; insulation between each coil, not just phase groups; coils are covered with moisture-resistant synthetic-resin and tung-oil sealer; entire winding dipped in synthetic-resin base varnish and baked; cooling air circulates through rotor core assembly.

For more data circle MD 27, Page 181

## SHAFT-POSITION INDICATOR 26

### . . . converts angular position to digital form

*Engineering Research Associates, Dept. A,* 1902 *W. Minnehaha Ave., St. Paul, Minn.*



Consisting of an electromechanical locator unit (shown) and an electronic converter unit, this device provides a pulse signal for control functions.

**Designation:** Shaft-Monitor.

**Size:** Locator, 16⅛ in. long, 5¾ in. wide, $5\frac{5}{16}$ in. high; converter, 19 in. long, 8¾ in. wide, $7\frac{3}{32}$ in. high.

**Service:** Converting shaft position to digit pulse output reading; accuracy, ± 0.09 deg; frequency, 20 readings per sec; input shaft may be rotated in either direction at speeds up to 120 rpm; output is in form of a train of negative, 30-v, 0.3 to 0.5 microsec pulses at 240 kc rate which may be used to perform control functions, or with visual indicators, magnetic recorders or tape or card-punch units; requires external power supply and rectifier.

**Design:** Magnetic recording mechanism records shaft position and controls time interval during which pulses are generated by a motor-driven index head; converter unit amplifies, frequency-multiplies and "shapes" the pulses—also contains control circuits; specials available.

For more data circle MD 26, Page 181

## SEAMLESS METAL HOSE 28

### . . . carries high-temperature liquids or gases

*Titeflex Inc.,* 500 *Frelinghuysen Ave., Newark* 5, *N. J.*

An ideal vibration eliminator, this flexible hose is of helical construction, so that flexing strains are minimized by distribution between inner and outer convolutions.

**Designation:** Uniflex.

**Size:** ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5 and 6 in. ID; supplied as hose and fitting assembly in measured lengths, or in random hose lengths.

**Service:** Carrying liquids or gases up to 450 F in temperature; withstands corrosion and abrasion; mechanical fittings, requiring no brazing or packing, distribute grip on hose over 4 or 5 convolutions; soldered fittings for temperatures to 300 F; braid-covered hose has high bursting strength.

**Design:** Seamless bronze hose, with helical convolutions; plain, single high-tensile bronze braid, or double-steel braid; rubber covering available; male fittings and unions, soldered or mechanical, for up to 2 in. ID; floating flanges for 2½ to 6 in. ID; female vibration absorber for all sizes; assemblies include refrigerating-unit charging hoses, automotive hose assemblies, water-cooled exhaust lines.

**Applications:** Plastic presses, refrigeration and air-conditioning equipment, tire molds, laundry machinery, locomotives, diesel engines, machine tools.

For more data circle MD 28, Page 181

# THE SHADOW of QUALITY...

## CAST BY STALWART RUBBER PARTS!

The quality of the components determines the performance of the finished product . . . and STALWART custom-engineered rubber parts are mass-produced to the highest standards. Various compounds have been developed which retain their physical, chemical and dielectric properties regardless of the effects of extreme temperatures, oil and gasoline, chemical action, abrasion or weather.

STALWART rubber compounds are supplied in precision molded, extruded, die-cut and lathe-cut shapes for application in aircraft, automobiles, trucks, marine equipment, railroad rolling stock, processing equipment, electrical assemblies, and other equipment.

Precision-fabricated parts can have varying degrees of hardness, tensile strength, and elongation to meet individual, S.A.E. or A.S.T.M. specifications.

Write today for the new 16-page illustrated catalog Number 51SR-1 for additional details.



400-SR

# STALWART RUBBER COMPANY

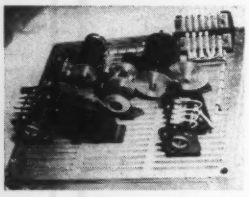
200 Northfield Road • Bedford, Ohio

# EQUIPMENT

## STANDARD COMPONENTS 29

### . . . for pretesting servo and computer designs

*Instrument Components Inc., 181 Lawrence St., New Hyde Park, N. Y.*



With these parts a laboratory setup of all mechanical elements in a computer, control or servo system can be made, and results tested before final production.

**Designation:** Belock Instrument.

**Service:** Testing and checking servo, control or computer assemblies; mechanizing tentative schematics; testing output accessories; parts are reusable.

**Design:** Parts available include mounting bases—standoffs, studs, bumpers and slides for mounting bases—brackets, hangers and hanger guides for shafts and components—shafting, shaft adapters, couplings, shaft clamps, collars and spacers—cranks, crank labels and crank clutches—mechanical limit stops and limit switches—dials and concentric dial assemblies—differentials, spur gears, bevel gears, split gears, cluster gears, spring-loaded gears and speed reducers—magnetic clutches—terminal blocks and accessories.

For more data circle MD 29, Page 181

## REPRODUCTION PAPER 31

### . . . for photocopying fine-detail drawings

*Eastman Kodak Co., Rochester 4, N. Y.*

Suitable for all types of contact photocopying equipment, this paper can be used for making reproductions or as a negative for cloth prints.

**Designation:** Kodagraph Contact Fine-Line.

**Size:** Sheet—5 x 7, 8 x 10, 8½ x 11, 8½ x 14, 9 x 12, 11 x 14 in. in packages of 100 or 250—11 x 17, 12 x 18, 14 x 17, 17 x 22, 18 x 24, 20 x 24, 24 x 36 in. in packages of 50 or 250; rolls—8½, 9, 12, 20 in. wide by 60, 100 or 250 ft long—24, 30, 36, 42 in. wide by 100 or 250 ft long; special sizes on minimum-order basis.

**Service:** Contact reproduction of very fine detail drawings, documents in poor condition, or printed halftone originals; can be used to make negatives for cloth prints or offset plates; produces crisp, clean lines and characters; wide latitude.

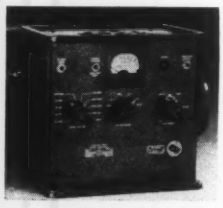
**Design:** Glossy surface reproduction paper in "thin" weight.

For more data circle MD 31, Page 181

## NOISE ANALYZER 30

### . . . measures sound level in octave bands

*General Radio Corp., 275 Massachusetts Ave., Cambridge 39, Mass.*



Effects of manufacturing variations on noise, faulty operation, or noise sources in machines can all be analyzed with this unit.

**Designation:** 1550-A.

**Size:** 11⅝ in. wide, 12$\frac{9}{16}$ in. high, 9 in. deep.

**Service:** Analyzing noise levels; range, 20 to 10,000 cycles in 8 bands—20 to 75 cycles (passes low-cycle noises), 75 to 4800 cycles in 6 octave bands, and 4800 to 10,000 cycles (high pass); 20 through 10,000-cycle band available at 2 switch position for calibration; level indication, to 60 db; input level, 1 to 10 v; source, sound-level meter, or directional microphone (over 70 db).

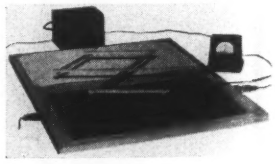
**Design:** Consists of filter unit and amplifier; meter calibrated from −6 to +10 db; attenuator covers 50 db in 10-db steps; level is sum of meter and attenuator readings; battery power supply, with ac power supply available as extra.

For more data circle MD 30, Page 181

## ELECTRIC-ANALOGY PLOTTER 32

### . . . solves two-dimensional field problems

*General Electric Co., Special Products Div., Schenectady 5, N. Y.*



An analogous electric field is set up, giving quick solutions to electrostatic, electromagnetic, thermal and fluid-flow problems.

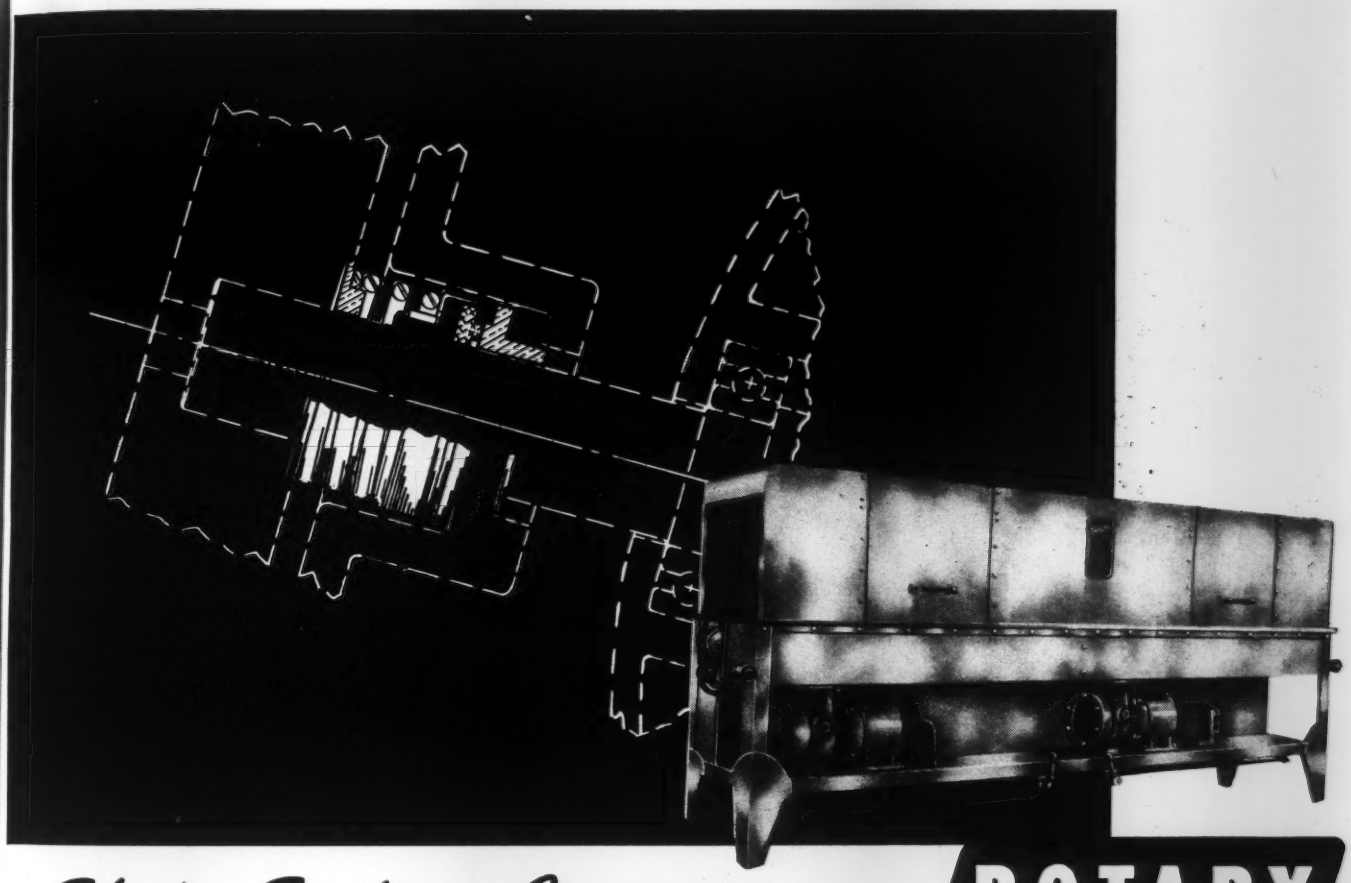
**Size:** Industrial model—31 x 42 in. plotting board; educational—23 x 31 in. plotting board.

**Service:** Solving field problems by electric analogy; dc power supply requires 115 v ac, 25 w.

**Design:** Electric field is set up across graphite-impregnated conducting paper, silver painted with cross-section of shape to be studied; multiturn voltage divider (potentiometer) adjusts potential at an exploratory stylus to zero, as shown on microammeter; stylus potential is then shown on voltage divider scale; educational model has pantograph (shown) for visual demonstration and reuse of conducting paper.

**Application:** Determining magnetic flux distribution and density around conductors; current flow and temperature distribution in conductors; air or fluid-flow patterns over airfoil sections or turbine blades.

For more data circle MD 32, Page 181



# *Shaft-Sealing Certainty* for ELKINGTON — with ROTARY SEALS

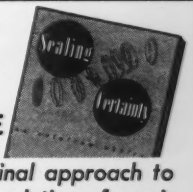
"Minimum maintenance, superior performance," says the headline on the data sheet in which Elkington Manufacturing Co., of San Francisco, describes the big Model HF-2 double tank automatic glass and dish-washing machine illustrated. And one of the features they put in ALL CAPS to back up that important "minimum maintenance" point is SPECIAL PUMP SEALS.

Those are ROTARY SEALS, as you might expect. You find them wherever equipment must stand up to rugged use-conditions — where only *Sealing Certainty* will do in continuous operation such as in the big government and civilian institutions which depend on these huge washers.

Whether your unit uses a shaft as tiny as a lead-pencil or as thick as your thigh, it's worth your while to learn how you can get *Sealing Certainty* with an adaptation of the basic ROTARY SEAL principle for your application. Our engineers, experienced in the solution of Shaft Sealing problems for manufacturers large and small in many widely varying fields, will be glad to consult with you on *your* requirements.

It's wise to call us in at the drawing board stage—we can often suggest the simplest design approach from the Shaft Sealing Standpoint, based on successful jobs in many lines.

**THE ROTARY SEAL PRINCIPLE**




*is the original approach to a practical solution of a universally troublesome problem. Our booklet "SEALING WITH CERTAINTY" explains and illustrates the principle. We're glad to send it to you without obligation.*

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

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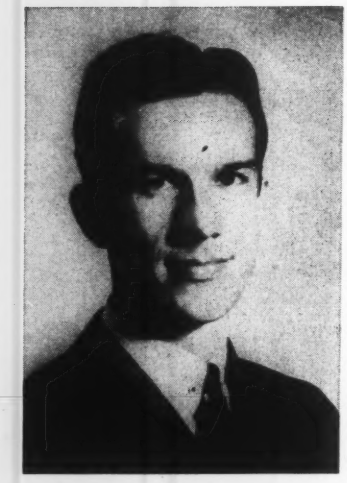
# MEN OF MACHINES



Dr. John T. Rettaliata

Formerly vice president and dean of engineering at Illinois Institute of Technology, **Dr. John T. Rettaliata** has been named president of the Institute. He succeeds **Dr. Henry T. Heald,** who is now chancellor of New York University. Dr. Rettaliata was also appointed president of the Armour Research Foundation of Illinois Institute of Technology and the Institute of Gas Technology. He received both his Bachelor of Engineering and his Doctor of Engineering degrees from the Johns Hopkins University. In 1936 he joined the Allis-Chalmers Mfg. Co., Milwaukee, as head of the calculation and development division of the steam turbine department and in 1944 was named manager of the research and gas turbine development division of the steam turbine department. He joined the staff of Illinois Institute of Technology in 1945 as director of the department of mechanical engineering. Dr. Rettaliata is the recipient of the junior award of the American Society of Mechanical Engineers, the Pi Tau Sigma gold medal award, and a special certificate of commendation from the Bureau of Ships for his study of steam turbines developed in Germany for hydrogen peroxide submarine operations. Last December he received a special award for "pioneering work in gas turbine development" from the ASME. Past chairman of the gas turbine power division of ASME, he is a vice president of that society and a member of the American Society for Engineering Education, American Society of Naval Engineers, Sigma Xi, Tau Beta Pi, Tau Omega, and an honorary member of Pi Tau Sigma.

♦

**H. Stanley Bimpson** has been appointed chief engineer of the steam turbine section of Allis-Chalmers Mfg. Co., Milwaukee. Mr. Bimpson, who has been a consulting engineer in the office of the director of engineering of the general machinery division, has had broad experience in the power plant field. After joining the company in 1920 he served in various capacities in the engine, condenser and blower departments, and later was named chief engineer of the Blower and Condenser department. Announced concurrently was the appointment of **Charles D. Wilson** as engineer in charge of steam turbine design. Mr. Wilson was previously in charge of large turbine design.

♦

John A. Borman

**John A. Borman** has been appointed chief engineer of The Baker - Raulang Co., Cleveland. He will have charge of administration of the engineering department, with regard to both new development work and production engineering. Mr. Borman graduated from Ohio State University in 1943 with a degree of Bachelor of Science in Industrial Engineering. Following graduation he entered the U. S. Army Corps of Engineers as a basic instructor in automotive maintenance and advanced to senior instructor and administrative officer. In 1946 he became associated with the Clark Equipment Co. at Battle Creek, Mich., as a welding engineer and tool engineer. He joined the Baker-Raulang organization in March 1950. His work there has included truck development co-ordination, from which position he advanced to chief of the development engineering section and later to chief mechanical engineer. Mr. Borman is a member of the American Welding Society and was vice chairman and chairman of the Western Michigan Section.

♦

At a recent meeting of the board of directors of Superior Coach Corp., Lima, O., **G. L. Runkle** was elected to the post of vice president of engineering. Mr. Runkle has a total of 22 years of experience in various phases of automotive engineering and production; during the past five years he has served as chief engineer for Superior. His new responsibility places him in charge of the company's engineering and tooling division in Lima and Kosciusko, Miss.

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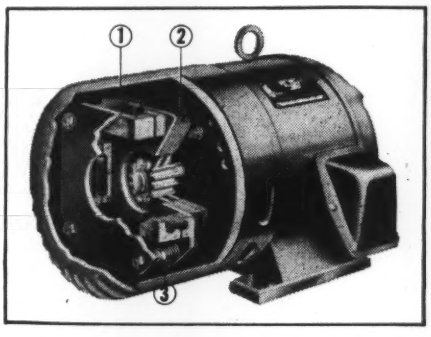
# BRAKEMOTOR DESIGN PROVIDES OUTSTANDING PERFORMANCE FEATURES

A number of unusual design and construction features contribute to improved service performance of a brakemotor built for frequent start-and-stop service.

As can be seen in the cut-away view, the magnets are firmly supported to cut down vibration and magnetic noise. Better heat dissipation results from mounting the magnets away from the motor frame.

Brake linings stop the motor smoothly and quietly, without screech. Fabricated of asbestos, these linings are not affected by weather conditions, and maintain stable frictional qualities.




*Cut-away view of Star-Kimble Brakemotor, showing magnets (1), brake linings (2), and retarding torque adjustment (3)*

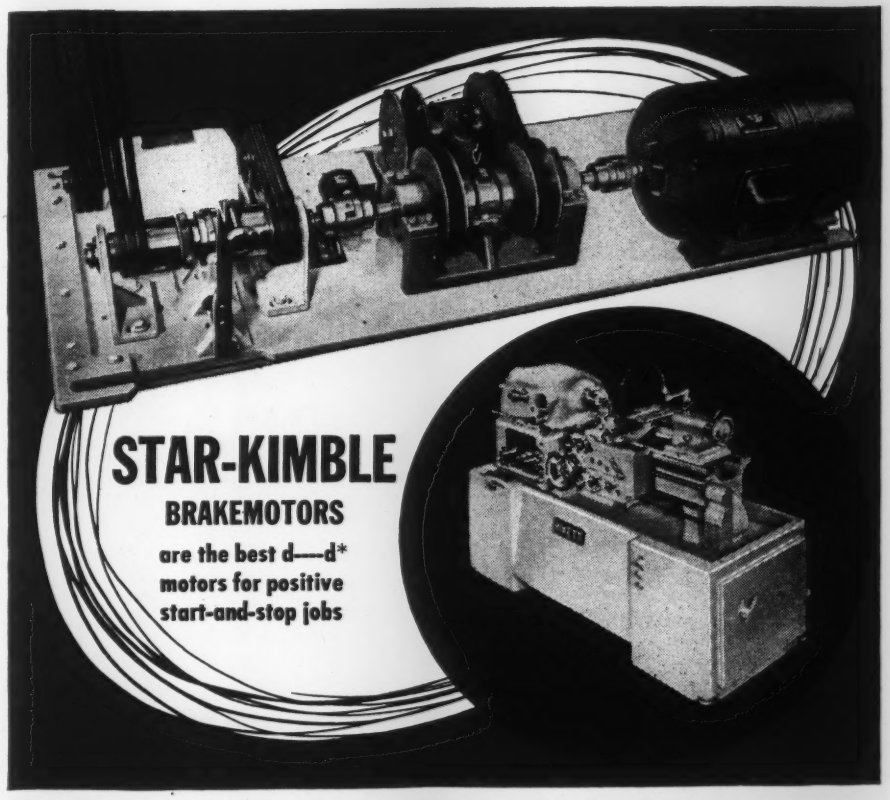
In average applications, the brake stops the motor within 1/5 to 1/2 second. Braking torque is easily adjusted by compression springs.

## AUTOMATIC RESET RELEASE

Brakes can be equipped with manual release which automatically resets itself when motor is re-energized, insuring dependable functioning of brake. This is an exclusive patented feature found only on Star-Kimble motors.

Since the Brakemotor is a single compact unit—not merely a motor with brake added — the over-all length is shorter. This simplifies mounting in cramped quarters.

Brakemotors include squirrel-cage, wound-rotor and d-c types in open-dripproof, totally enclosed non-ventilated and totally enclosed fan-cooled constructions. Complete details are given in Bulletin B-501-A, available on request from Star-Kimble Motor Division of Miehle Printing Press and Mfg. Co., 201 Bloomfield Ave., Bloomfield, New Jersey.




# CARRIAGE TRAVEL LIMITS HELD WITHIN .002"

## ...with Star-Kimble Brakemotors on Rivett Precision Lathes

Designed throughout for exceptional accuracy in both toolroom and production work, the 1020S Precision Lathe built by Rivett Lathe & Grinder, Inc., Boston, Mass., provides for stopping the carriage travel by means of limit switches. These switches control the power supply to a Star-Kimble Brakemotor.

Precision dial indicator shows the accuracy with which the Brakemotor stops the carriage at the predetermined point. According to the Chief Engineer of Rivett, the stop mechanism of the lathe has been operated an almost unlimited number of times. Accuracy of the stop has been *within .002"*, every time!

In thread cutting, the fast, accurate stopping of the Brakemotor permits the thread to finish up at identical positions on piece after piece.

Wherever applications call for accurate, positive, split-second stops—and *particularly* for repeated starts-and-stops in the toughest of duty cycles—Star-Kimble Brakemotors have proved their ability to run for years with little or no attention.

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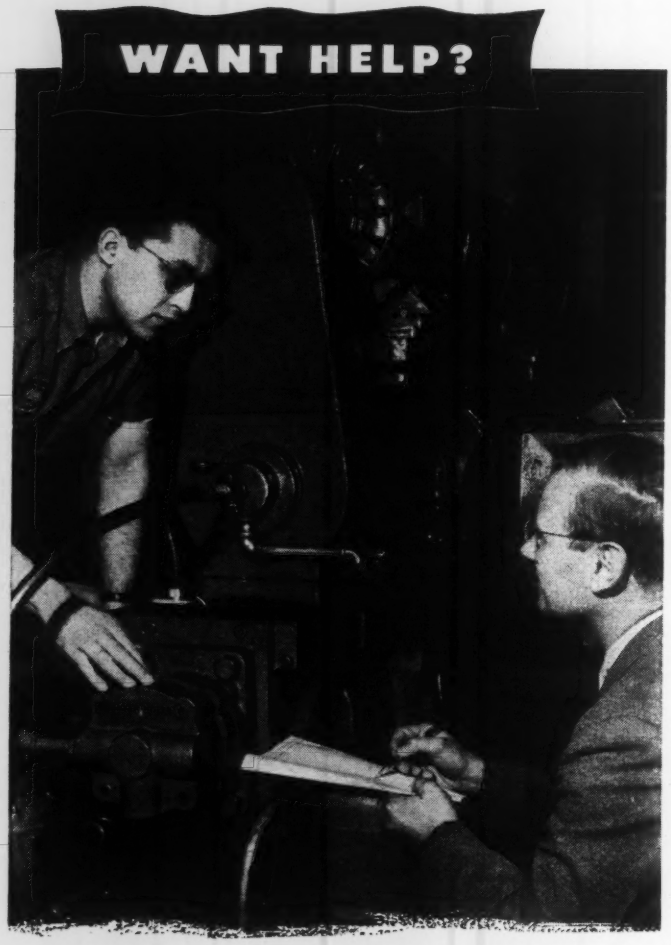


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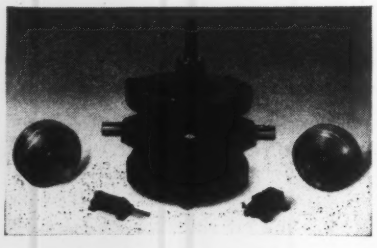
For this help, call today or write Anker-Holth Division of The Wellman Engineering Company, 2725 Conner Street, Port Huron, Michigan.

Above: Anker-Holth Model HH Hydraulic Cylinder installed on a Gardner Grinder.



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# THE ENGINEER'S Library

### Fundamentals of Automatic Control

*By G. H. Farrington, consultant engineer; published by John Wiley & Sons Inc., New York; 285 pages, 5½ by 8½ inches, clothbound; available from* MACHINE DESIGN, $5.00 *postpaid.*

This general survey of the wide field of automatic control deals with underlying principles affecting control performance, rather than specific details of apparatus. Since fundamentals only are covered, it will usually be necessary to adopt simplifying assumptions for design. This in turn requires a clear understanding of the difference between actual conditions and those expressed by the mathematical representation. Subject matter on applications has been omitted, except for particular examples introduced solely to clarify basic principles.

The basic control system, various types of control, and transfer stages are considered first, with system equations and an investigation of load changes following. Transmission lines, plant characteristics, multiple control, and discontinuities are then reviewed. Final chapters deal with plant analysis, analysis of controlling units, and control selection and adjustment.

□ □ □

### Finite Deformation of an Elastic Solid

*By Francis D. Murnaghan, professor, Instituto Tecnologico de Aeronautica, Brazil; published by John Wiley & Sons Inc., New York;* 140 *pages; 5¾ by* 9 *inches, clothbound; available from* MACHINE DESIGN, $4.00 *postpaid.*

A mathematical treatment of the theory of finite deformation of an elastic solid, this book methodically uses the matrix concept in presenting the subject material. An essential feature is the consideration of squares and higher powers of the strain components in the theory of elasticity. The assumption is not made, as it is in the classical infinitesimal, or linear theory, that the deformation is so small that the squares and products of the strain components are negligible.

The introductory chapter presents an account of the relevant properties of matrices used in the book. Succeeding chapters present: the specification of strain, the connection between stress and strain, isotropic and nonisotropic elastic media. These first six chapters are presented in textbook form with problem exercises for each topic covered. The concluding

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* Famous, time-proven *Vernatherm*, a thermostat employing a special power-creating substance highly sensitive to temperature variations, is the same element used by DETROIT in the manufacture of water mixing valves for automatic washing machines, commercial dishwashing machines, photographic developing machines, diesel, gasoline and jet engine thermostats, aircraft oil cooler controls, and transmission oil cooler controls.

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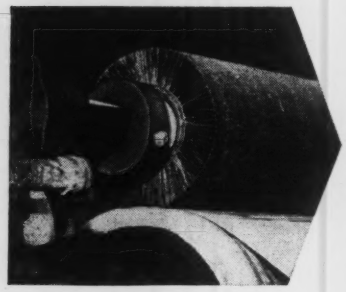
## How Pittsburgh Brushes SPEED PRODUCTION

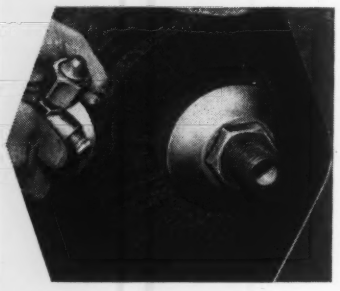
### 1. Removing oil film from steel!



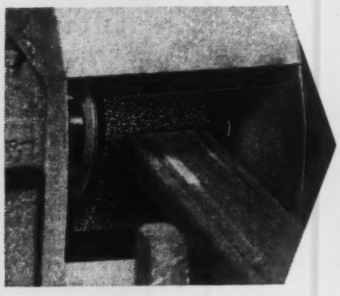
Crown Cork & Seal Co., Inc., asked Pittsburgh engineers to recommend a brush suitable for washing oil film from steel before annealing. A "built-up" brush made of Tampico sections was installed. Oil and foreign matter were completely removed without harming the surface of the steel. Production showed an immediate increase, and time saved due to fewer brush replacements added to the overall savings.

### 2. Satin-finishing brass fixtures!

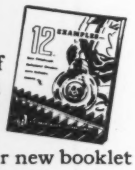
Frequent breakdowns and brush changes hampered Bastian-Blessing Company's production of satin-finish parts for its products. Pittsburgh engineers recommended a crimped steel, standard 10" brush. Reports after three years' use show Pittsburgh Brushes have increased production, improved quality and saved materials . . . while lasting *three times longer* than previous brushes!



### 3. Removing burrs from steel!



Problem: The National Electric Company needed a brush to eliminate burrs and scale, yet the brush had to combine cleaning ability with long life. Solution: Pittsburgh designed a brush to specifications—a brush that was stiff and tough enough to penetrate, clean, and remove burrs and scale, and rugged enough to stand up. Result: An increase in efficiency; a jump in production!



***Let Pittsburgh Engineers Solve Your Brush Problems.*** Pittsburgh's complete line of brushes of every type, for every purpose, will provide a practical and economical solution of any brush problem you might have. Drop us a line on your company letterhead for a copy of our new booklet that shows, through actual case histories, how Pittsburgh brushes help cut your operating costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W-1, 3221 Frederick Ave., Baltimore 29, Md.

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chapters deal with simple shear and tension and the application of the theory to the problem of deformation of spherical shells and circular tubes under extreme external and internal pressures.

## Association Publications

*A Basic Training Manual on Statistical Quality Control:* Consisting of a brief text and a large number of work sheets, this manual has been written for use in plant-training or technical-society courses in quality control. The heart of the manual is a series of work sheets covering frequency distributions, control charts, fraction defectives, per cent defective charts, sampling (including charts given in various military specifications), and a group of sheets showing how charts are constructed and how quality-control charts are used in various applications. The approach is strictly practical, omitting all theory in order to present directly usable quality-control methods. Written by Rudolph Freedman and Joseph Movshin with the co-operation of the Department of Industrial Engineering at Washington University, the 77-page manual is 8 by 10¾ inches in page size and is plastic-ring bound. Copies are available at $2.50 each from the St. Louis Society for Quality Control, 6651 Kingsbury Ave., St. Louis 5, Mo.

## Manufacturers' Publications

*Mallory Resistance Welding Data Book:* Containing 510 pages and over 1000 illustrations, this fourth edition has been rewritten to incorporate developments in resistance welding in the past seven years. The first half of the book is made up of three sections covering: fundamentals of resistance welding; resistance welding controls and equipment; and materials to be welded. Following these basic sections are four sections dealing with: alloys for resistance welding applications; resistance welding electrodes, dies, and holders; the silver brazing of Elkonites to Mallory copper-base alloys for resistance welding applications; and recommended practices for resistance welding. The concluding section presents miscellaneous tables and data. Size of this cloth bound book is 6 by 9 inches; available from P. R. Mallory and Co. Inc., Welding Division, Indianapolis 6, Indiana; $3.00.

*Alloys in Cooperland:* "'The time has come,' the Walrus said, 'to talk of many things: But most of all of stainless steel . . .'". This quotation introduces the story of a trip through a stainless steel foundry. Included in the itinerary are the pattern shop, foundry, research laboratory, cleaning room, machine shop, and shipping platform; all operations in fabricating stainless steel castings are briefly explained. Although mainly concerned with Cooper's products, this booklet, printed in full color and cartoon illustrated, is a novel and refreshing presentation. Size of the booklet is 7½ by 9½ inches; copies may be obtained by users of stainless alloys from The Cooper Alloy Foundry Co., Hillside, N. J.

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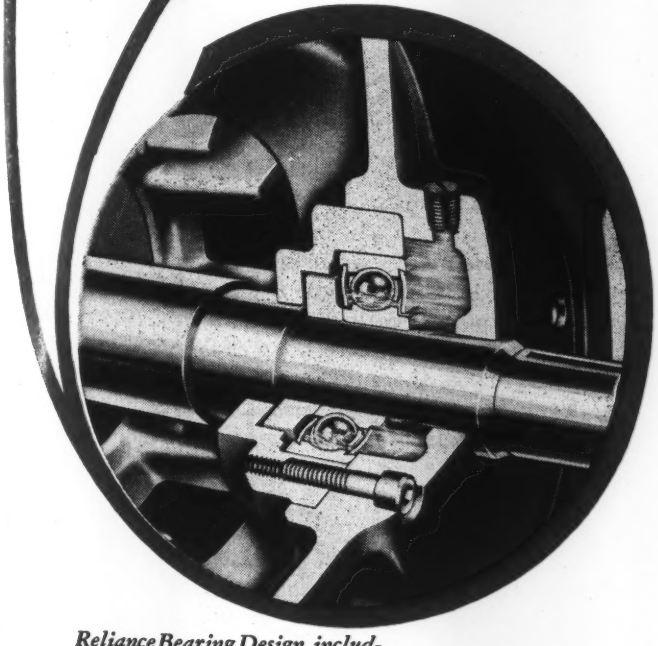
*Reliance PRECISION-BUILT A-c. Motors from 3/4 to 300 hp.*



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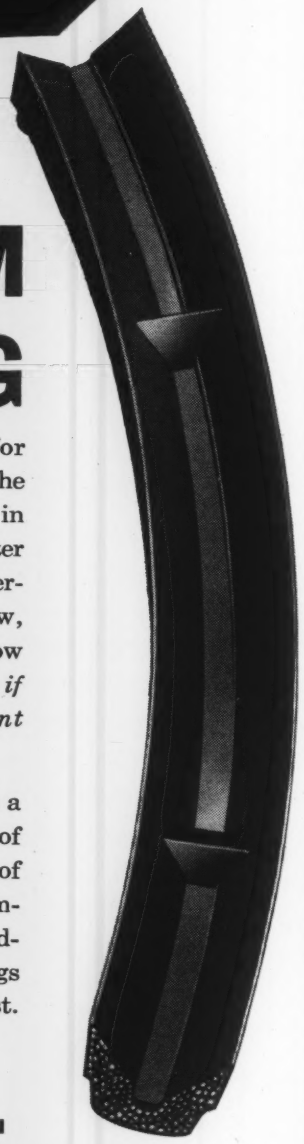

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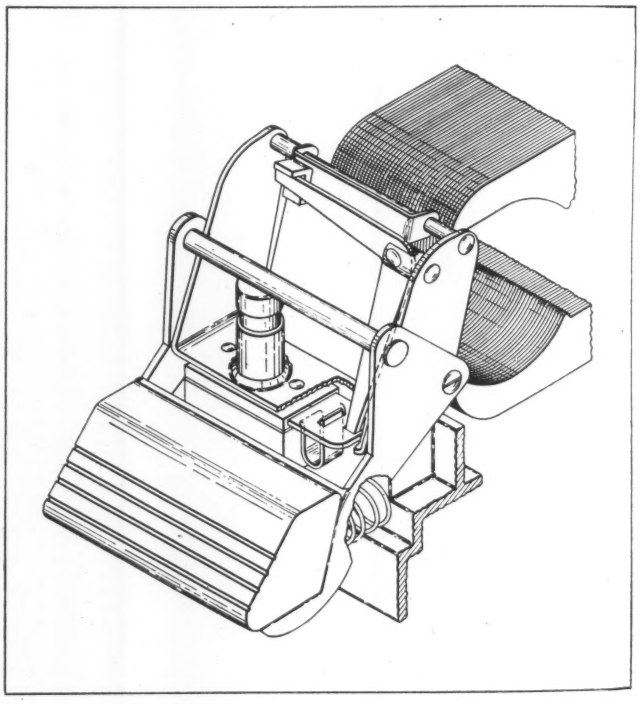
# NOTEWORTHY Patents

**MOTOR ENERGIZED** switch-holding mechanism prevents starting of appliance motors by inadvertent plug-in of the service cord. When the motor switch is operated, a linkage arrangement connecting the switch slide to a hinged armature causes the latter to swing into contact with the motor field poles. If the motor field is not thereby energized, or later becomes de-energized because of power failure or cord pullout, a U-shaped spring resets the switch to "off" position, automatically. This safety device was designed primarily for use on a floor polisher wherein the weight of the appliance normally rests on the power-driven polishing brushes. Patent 2,574,965 assigned to the Hoover Co. by Dale C. Gerber.



**TAPERED TRUNNION ROLLERS** eliminate sliding friction in a universal joint designed to transmit rotary motion at constant angular velocity. Transmission from driving to driven shaft is through split housings clamped together with bolts passing through elongated clearance slots in ball-shaped ends of each shaft. Annular grooves are machined inside the housings to guide the rollers, and spherical sockets are provided to hold the shafts in relationship endwise. One of the ball-ends contains a guide hole to receive a small pilot ball mounted on the end of the other shaft. This arrangement causes both shafts to operate

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Light weight: ½ weight of Al, 1/7 weight of brass. Lighter, more modern gears for modern machines.

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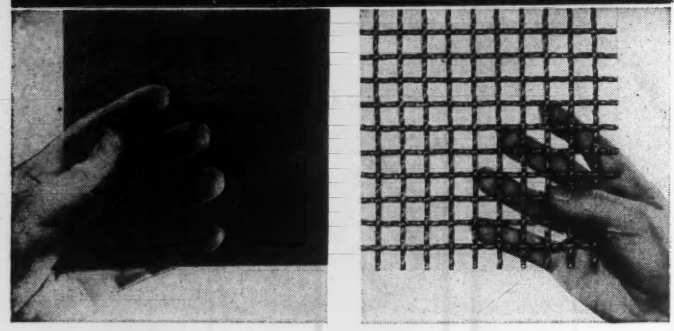

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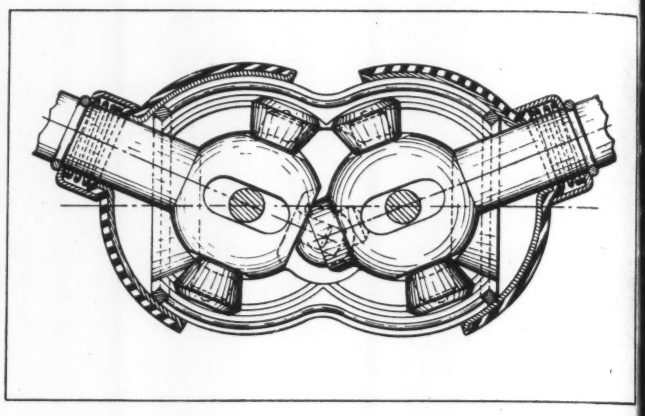
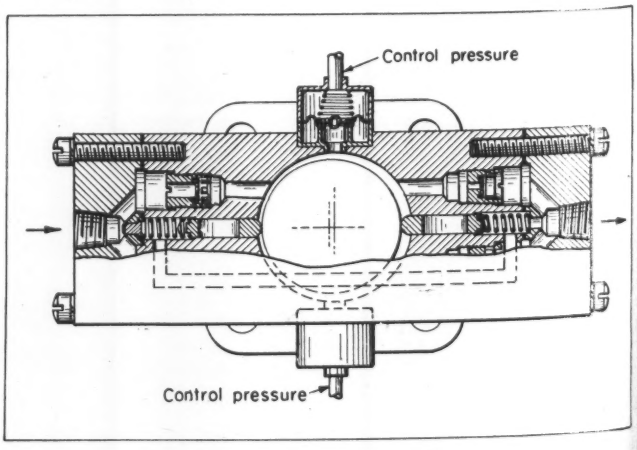
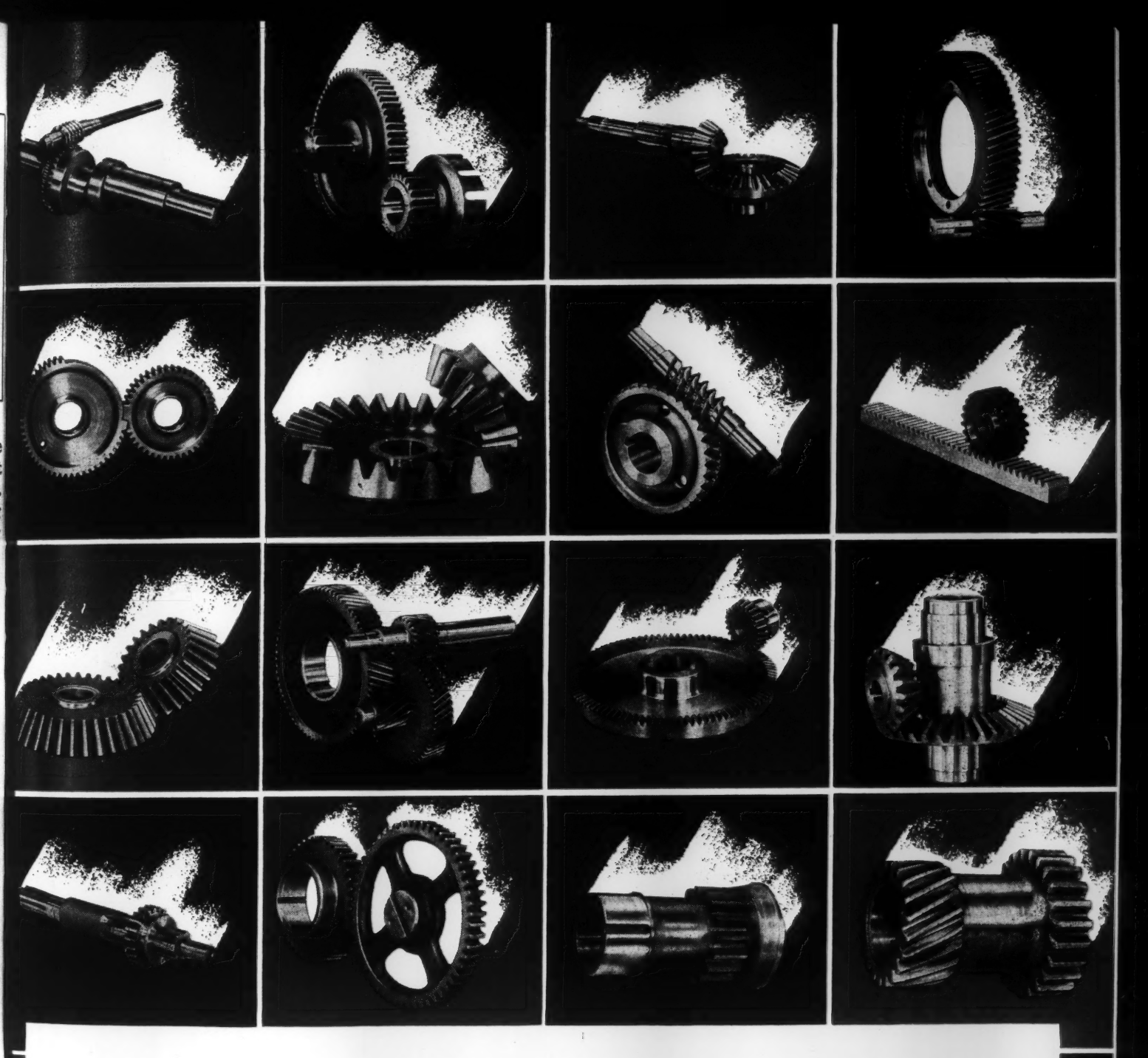


at equal displacement angles with reference to the housing centerline, resulting in equal speed of input and output shaft throughout all degrees of rotation. Spring-loaded shells, held on the shafts by retaining rings, fit the spherical outside surfaces of the housing to close up the end holes and exclude dirt. Diamond-section wiper rings held in contact with the closure shells prevent excessive loss of lubricant. Patent 2,574,226 assigned to General Motors Corp. by Frederick W. Sampson.

**EXPANSIBLE CHAMBERS** in a fluid pump eliminate the bypass circuit used ordinarily to dispose of displaced fluid prevented from escaping through the discharge ports. One of the several chamber designs delineated in the patent contains a spring loaded diaphragm with provision for auxiliary loading by superatmospheric control pressure. Pumping compartments of the eccentric-rotor pump are separated by two spring-loaded blades which are held in contact with the rotor by having the outer end of the blade exposed to discharge pressure. If fluid discharge is blocked while the pump is running, fluid merely passes back and forth between the pumping sections and the expansion chambers, and is readily available on demand at the discharge ports. This action is said to avoid the formation of vapor often generated in bypass-circulated volatile fluids such as gasoline. Inlet and outlet check valves are contained in threaded cartridge assemblies inside the pump body. Patent 2,513,833 assigned to Bendix Aviation Corp. by Albert H. Winkler.





# IT'S YOUR MOVE...

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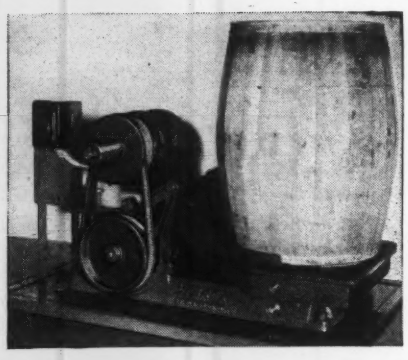

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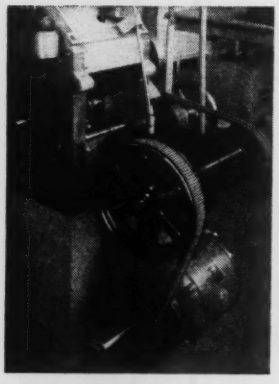
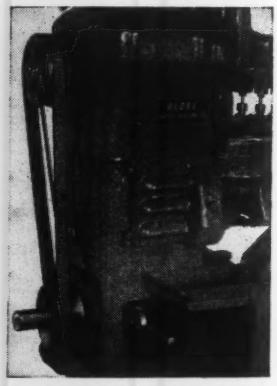


Lovejoy countershaft Unit controls speed of automatic Spring Coiler



Lovejoy Wide V-Belt Pulley provides infinitely variable work-speed control on Tapping Machine.

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# Welded Gear Blanks

(*Concluded from Page* 142)

this limitation must be considered in design. If the gear has a narrow face, the single-web design must be used. Double-web construction, however, is usually employed on gears with wider faces, because distortion is reduced to a minimum. This type of gear blank also provides additional rim support and greater resistance to loads in the axial direction. To assure minimum rim distortion, web plates should be located as in *Fig.* 5. Size of access holes in the web plate should be kept to a minimum to resist distortion between holes, *Fig.* 6.

Tendencies toward distortion cannot be eliminated by adding radial stiffeners to the gear blanks, since they only support the rim at one place, and the rim distorts between them. Web distortion resulting from service loads and press-fit stresses, however, can be prevented with web stiffeners, *Figs.* 2 and 3. These web stiffeners not only help prevent distortion in the axial direction, but also provide additional rigidity to resist cutting and service loads. If these stiffeners are not added, the rim may weave, seriously affecting tooth action.

If welded steel gears are to replace cast steel gears, general design of the cast steel gears should offer an excellent guide to the proportions of the welded gears. In general, cast steel gear designs are based on experience, and were developed to resist the same residual stresses that create distortion in welded steel gears.

---

# Supertanker Steers Safely

NEW safety features and other innovations designed into the steering-gear hydraulic power system of the *SS Atlantic Seaman,* a 30,000-ton supertanker, are indicative of recent advances and improvements made in the application of hydraulics to marine duty.

The steering gear proper is of conventional electric-hydraulic type manufactured by the Hydraulic Press Mfg. Co. with horizontal opposed rams connected to a crosshead on the rudder stock. It is powered by a radial-piston oil hydraulic pump, driven by a 125-hp, 900-rpm induction motor. The pump operates constantly, maintaining required pressure at all times. In emergency, a specially designed six-way valve in the steering unit permits shifting from the pump currently in use to a standby pump within less than 30 seconds.

If there is a complete power loss on the ship, the steering gear rams are locked by throwing the six-way valve into neutral, and the rudder is prevented from moving and taking charge. A servo control helps prevent the rudder from overhauling the power pump, eliminating the necessity for a rudder brake or other emergency tackle. Provisions have been made so that in case of an emergency, the rudder may be positioned by an auxiliary hand pump.

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# Trade Secrets

(*Continued from Page* 146)

those powers remains the employee's property unless curtailed through some restrictive covenant entered into with the employer."

This decision of the Pennsylvania court followed as authority an earlier case in that state in which the court had said, "It may now be accepted as settled law under the authorities of English and American cases, that courts will restrain an employee from making disclosures or using trade secrets communicated to him in the course of confidential employment.

"Character of the secrets, if they are peculiar or important to the business, is not material. They may be secrets of trade, secrets of title or secrets of process of manufacture, or any other secrets important to the business of the employer. They, however, must be the particular secrets of the employer, not general secrets of the trade in which he is engaged, nor even the same secrets as those sought to be protected if they have been discovered by the independent investigation of outside parties."

> ***. . . the duty of an employee to hold in confidence any knowledge of trade secrets acquired during his employment is an essential feature of the relation of employer and employee . . .***

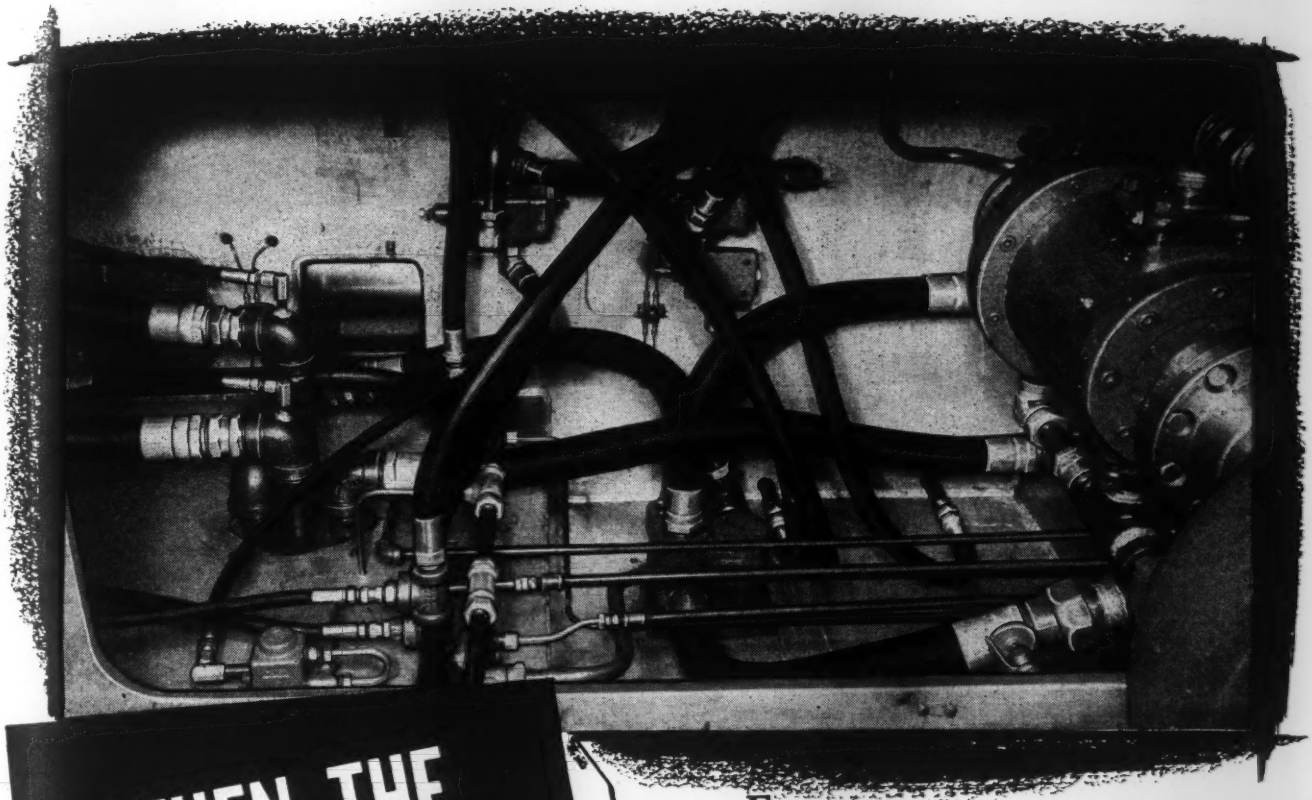
Protection granted by the courts in these cases is against a breach of confidence by employees or others in disclosing information entrusted to them which they have, either expressly or implicitly, undertaken to hold in secret.

The principle of the law that forbids disclosures, however, relates solely to the knowledge and information of trade secrets—information communicated in confidence. It does not relate to the general knowledge and skills the employe acquires in his work.

President Taft, when a federal judge, said in a decision of a case of this character, "It would be a violation of every right of an employee of a manufacturer to prevent that employee from using in a business of his own, knowledge he had acquired when he might have acquired that same knowledge in the employ of other manufacturers. In every case where the employer seeks protection for a trade secret it must appear that it is really a secret."

No patent is needed for the protection of a trade secret from disclosure by a breach of trust, asserted Justice Holmes in a United States Supreme Court decision. In this case a man employed by a manufacturer of instruments later patented the instruments in his own name. This employee had been entrusted with secret information about the construction of these instruments on his agreement to hold such information in confidence.

The lower court in this instance rendered a similar verdict. The right of the courts to forbid the dis-



# WHEN THE PRESSURE'S ON

## easily, efficiently, safely

EXTRA safety, unusual dependability — that's what the manufacturer of this 25-ton 66" Double Ram wanted. And that's why he specified Anchor Ductile Sleeve Couplings and Hose. Like many other manufacturers of machinery using hydraulic systems, he knows Anchor's exclusive patented grip makes the coupling virtually a part of the steel reinforcing wire of the hose — eliminates leaks and troublesome blow-offs.

HERE ARE ADDITIONAL REASONS why Anchor two-wire braid high-pressure hose assemblies were selected for this tough job:

- ☆ They reduce maintenance and service on piping to practically nothing.
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Anchor also makes a complete line of adapter unions and related fittings for practically every pressure or suction job. Take advantage of the many outstanding features in the most complete line of hose assemblies and fittings available. Benefit by the plus margin of safety and the greater dependability offered by Anchor.

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# RACINE HYDRAULIC PUMPS

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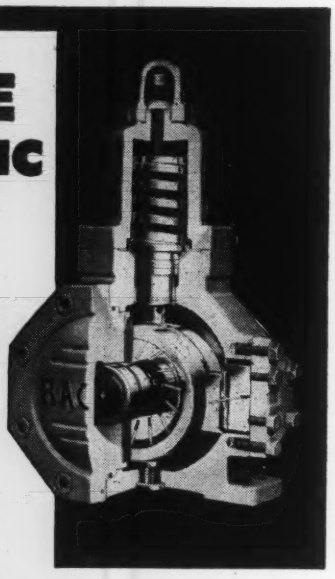

Less valves and controls in a circuit provide easier installation and lower initial costs.

RACINE "Variable Volume" Pumps eliminate relief valves and extra piping. They reduce horsepower requirements and avoid excessive heat losses. Over-all cost of motor and reservoir is usually reduced. Efficiency is high because RACINE Pumps "put all of the oil to work."

A wide range of governor controls provide pumping action at the proper pressure and volume to handle any given job most effectively. These interchangeable governors are an exclusive RACINE feature.

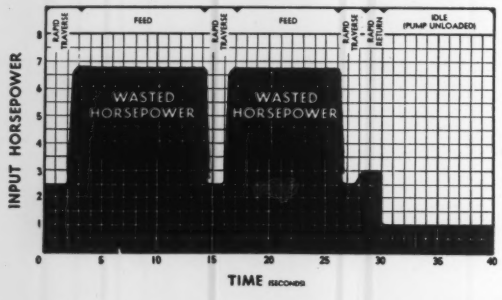


*Chart above illustrates power consumption on a typical machine tool. Black area is power used with a No. 2 RACINE "Variable Volume" pump controlled by a pressure compensated feed valve. Area in color is power wasted by a constant volume pump, bypassing most of its volume though a relief valve during the feeding cycle.*

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Pressure Boosters

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closure of trade secrets is not the assertion of a patent right, said the court. A fundamental principle of law forbids a wrongdoer from profiting by the disclosure of information obtained under circumstances that obligate him to keep the information secret.

"A trade secret may be a device or a process which is patentable but it need not be patentable," said a New York court in a similar decision. "Novelty and invention are not requisite for a trade secret as they are for patentability. The protection is merely against a breach of faith and against reprehensible means in the learning of another's secret."

In this instance a New York airplane manufacturer sued to prevent the disclosure of a secret process for applying layers of aluminum to cast iron and other ferrous metals in the production of aircraft engine cylinders. An employee, dissatisfied with his relations with his employer, had negotiated with a competitor for the disclosure of the process.

In granting an injunction against this disclosure the New York court said that an employee is not permitted to appropriate the property of his employer.

**. . . character of the secrets is not material. They, however, must be the particular secrets of the employer . . .**

What he acquires in confidence he may not divulge. A secret persists even after termination of the relationship under which it was acquired. "Employees may not gain knowledge of a secret and then avail themselves of it for their own advantage against their employer."

A Chicago candy manufacturer perfected a machine for enclosing packages of candy in a wrapping with a cellophane insert by which the purchaser could see the contents of the package. The use of an all-cellophane envelope had at that time proved unsatisfactory.

Wrapping of this candy manufacturer's product was being done by an outside company. An executive of the candy manufacturer told a representative of the wrapping company, in confidence, the details of the construction of the machine. A few days later the wrapping company sought permission to use this machine on condition that all information in regard to its construction should be held by them in strict confidence.

With this understanding, the details of the machine were disclosed to the wrapping company with the agreement that later a formal contract would be drawn up and executed. No patent had been issued or applied for at that time.

Negotiations for the licensing of the machine to the wrapping company failed, and no contract was executed. The wrapping company, however, discovered from a Patent Office search, that a patent had been issued on a similar machine. It purchased this patent and proceeded to make these machines until suit was brought by the candy company to forbid use of this patent.

The wrapping company had here legally purchased

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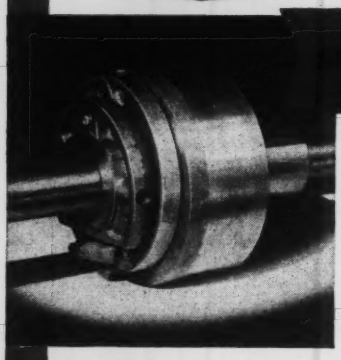
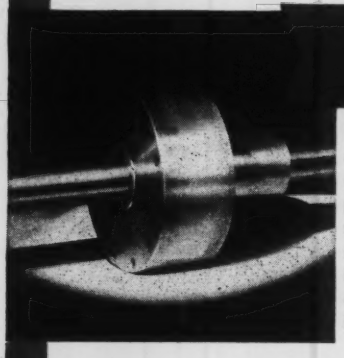
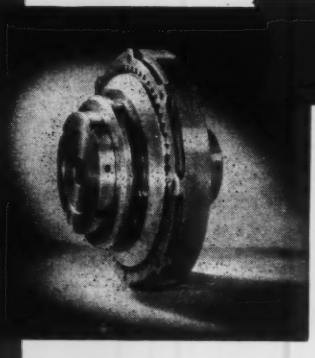


Unequaled for accurate control of intermittent machine operations—cutting, punching and packaging. Gives closer tolerances to cut-off, stamping, shearing and similar machines. Completely automatic; manual, mechanical or electrical control.



Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unsurpassed for automatic two-speed drives, dual drives, stand-by drives and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.



A reliable series of spring-loaded slip clutches and couplings. Rugged construction with ample friction surface for heavy-duty use. Outstanding for preventing overloads and shocks; for starting heavy loads; as tension drag brakes; for reeling and winding operations and many other uses.

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the patent for these machines, but it had done so by using the confidential knowledge it had received from the candy manufacturer.

The crux of the situation, according to the court, was in the validity of the acts of the wrapping firm in: (1) receiving, under an agreement to treat the same as confidential, a disclosure of the candy manufacturer's secrets (2) using them to locate the patent; (3) constructing its machine to make a machine like that of the candy manufacturer; (4) procuring an assignment of a patent it claimed covered the invention and; (5) refusing to account to the owner of the secret.

"It is well established," continued this court in deciding against the wrapping firm, "that the law will enjoin the use and disclosure of trade secrets learned in confidence. The principle of the protection of such trade secrets is founded upon trust and confidence.

"Whether the subject matter is patentable or not, if the inventor discovers and keeps secret the design or method of construction of a machine, though he will not have an exclusive right to it as against the public after he shall have published it, or against those who in good faith acquire knowledge of it, yet he has a property right which a court will protect against one who, in bad faith or breach of confidence, undertakes to apply it to his own use."

> ***. . . in every case where the employer seeks protection for a trade secret, it must appear that it is really a secret . . .***

The iniquity of an employee who takes away with him the property of his employer in the form of trade secrets is as clear as if he took away any other property, asserted the Federal District Court in a decision involving a breach of confidence of this type, and to this Justice Holmes of the United States Supreme Court said, in sustaining that decision;

"Whether the employer has any valuable secret or not, the employee knows the facts, whatever they are, through a special confidence that he accepted. The property in the secret may be denied but the confidence cannot be. The first thing to be made sure of is that the employee shall not fraudulently abuse the trust reposed in him."

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2. Pittsburgh Cut Wire Co. v. Sufrin, 38 A. 2d 33, Pennsylvania
3. Macbeth-Evans Glass Co. v. Schnelbach, 86 Atl. 688, Pennsylvania
4. Allen-Qualley Co. v. Shellmar Products Co., 31 Fed. 2d 293
5. E. I. DuPont de Nemours Powder Co. v. Masland, 244 U.S. 100, aff'g. 216 Fed. 270.


"Business success is like happiness . . . you can gain it only by giving it. I do not know how any honest business can prosper without adding to the prosperity and welfare of our whole society; nor do I know of any lawful enterprise that has ever achieved success without contributing to the success of others."
—BENJAMIN F. FAIRLESS, *president, U. S. Steel Corp.*

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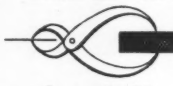
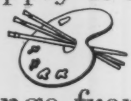
For whatever your need or specifications, we will process **FELT** from downy softness to maple board hardness . . . supply it in any thickness . . .  dye it  any color, any shade in the full range from black to white . . cut it into *precision* parts to your most exacting shape and size requirements . . . or ship it to you by the roll, by the sheet, or in yardage.

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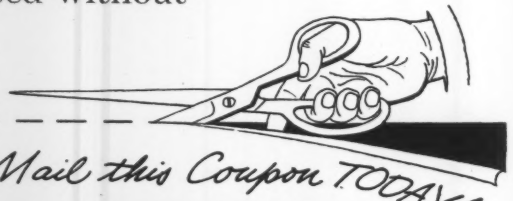

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REPORT ON

# Materials

SEVEN materials have now been removed from government controls—and more will follow "as soon as new and expanded facilities are able to meet both defense and civilian requirements."

The above statement from Henry H. Fowler, who has succeeded Manly Fleischmann as administrator of the National Production Authority, emphasizes the agency's recently announced policy of relaxing or revoking orders and regulations as rapidly as supplies are available.

Mr. Fowler continued, "Sometime during 1953, our defense expansion program should be largely complete and our stocks of essential materials should be high. When that time arrives, we can hope for a civilian economy that is relatively free from controls. . . "

The seven materials decontrolled are straight chrome stainless steel, GR-S synthetic rubber, plastic-type nylon, bismuth, glass containers, methyl chloride, and sole leather. Certain inventory or production restrictions still continue on all.

Increases in reserve stocks were given as the reasons for all decontrol actions. Thus, inventories of government-produced GR-S synthetic rubber rose from 44,700 long tons in March, 1951, to 99,400 long tons in December. Restrictions on butyl (GR-1) synthetic and natural rubber, which are in shorter supply, still continue.

**Plastic as a Replacement:** Many metals are due to go through a period of tight supply in mid and late 1952 before the pressure is relieved in 1953 or 54. As metals grow tighter, the structural reinforced plastics will grow in importance. Basic materials for most reinforced resins—phenolics, melamines, alkyds, polystyrene, silicones and polyesters combined with cotton, rayon, nylon, glass or paper—are in comparatively good supply, although at present under materials controls.

Polyester resin reinforced with

glass fiber is growing in significance as a structural material. In 1951 polyester resin volume was about 14 million pounds. If all facilities suitable for production were used, polyester resin output today could be pushed to 24 million pounds, and to 27 million pounds by the end of the year. With the entrance of several new companies into the field and the expansion of present plant facilities, production of glass fiber should have no trouble keeping up with any increased pace.

Phenolic resins, also in adequate supply, are attractive possibilities in many applications, since wide latitude of physical properties is possible. Not only can various filler materials be selected, but the basic properties of the resin itself can be altered to meet service requirements. Among the newer modifications is the addition of synthetic rubber to increase impact strength. Furfural-modified phenolics may be used for parts requiring deep drawing. Aniline oil may be added to the resin for superior electrical properties.

**Steel Supply Eases:** In many sections of the country the pressure on steel seems to be lessening. Although no great surpluses exist (except for certain specialty steels) the demand for many garden-variety mill products has eased in specific cities and localities.

In Detroit—affected by restrictions on automobile production—light-gage plates, cold-rolled sheet, the smaller structurals and small hot-rolled carbon bars are reported to be plentiful. In Chicago, light plates, sheets and strip seem to be easing. Some mills on the East Coast report a similar slackening of demand. The squeeze still seems to be present on the larger and heavier sizes and on large bars and forging billets.

A new development in alloy steels is the use of a misch-metal alloying ingredient to reduce hot shortness. The rare-earth compound, containing mainly lanthanum and cerium, was primarily developed to increase the forgeability of stainless steels. In alloy steels, also, addition of the compound permits reduction of the nickel content. In cast-steel armor plate, for example, nickel content has been

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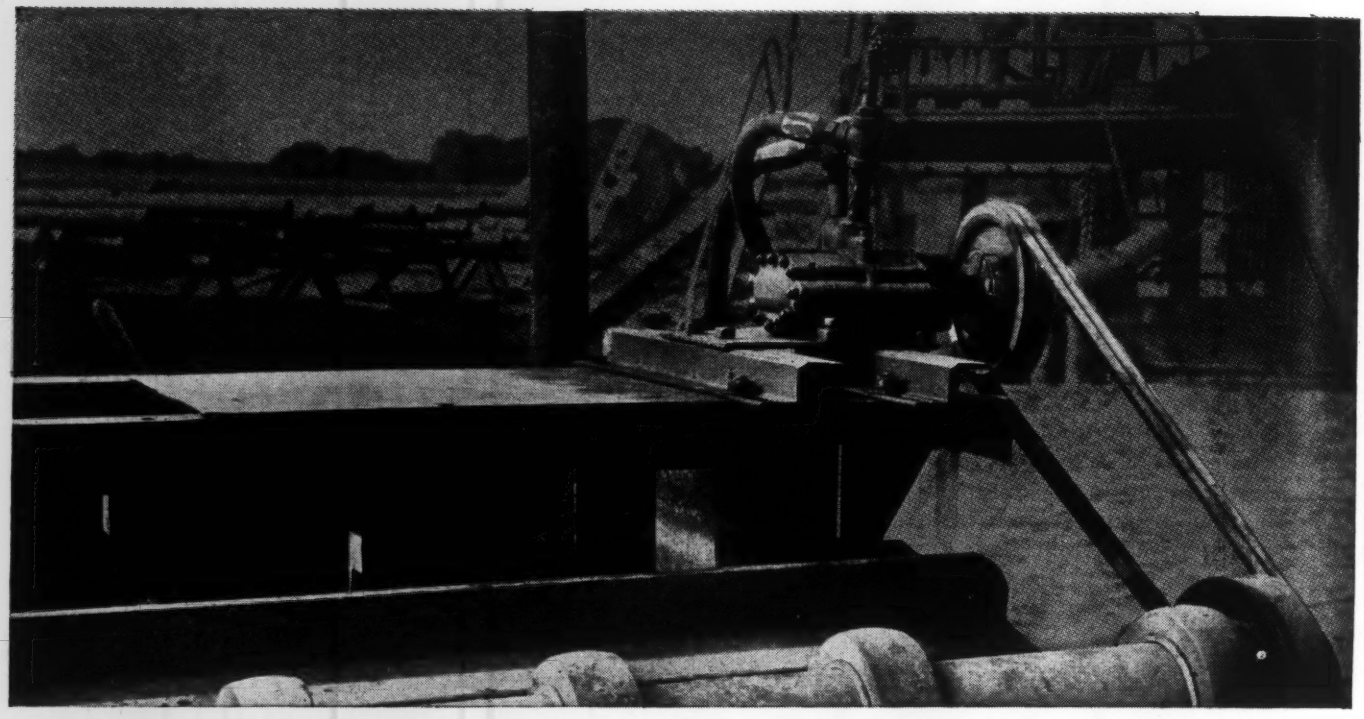

# NEW hydraulic transmission sets record endurance mark!

Powering a vibrating screen on an oil well drilling location in Oklahoma, a single place 1400 series Berry fluid motor recently withstood vibration of 2200 cycles per minute, for over 20,000 continuous hours.

At the end of that period, the Berry unit had merely lost some efficiency from normal wear. Because of the simplicity of its design, the Berry hydraulic motor survived visible vibration where every previous installation had failed.

Belt-driven from the power take-off of the main oil well power rig, a single place 1400 series Berry pump furnished oil under pressure to the Berry motor—100 feet away—through hydraulic lines. The motor agitated the vibrating screen by means of an eccentric, thus creating the necessary vibration which the motor itself had to withstand.

The ability of the Berry motor to shrug off intense vibration testifies to its rugged qualities — qualities that make for economy, ease of maintenance and long life in *any* application.

If you have a power transmission problem, investigate the Berry solution—a modern, simple solution that is proving itself in installations such as auxiliary drives on trucks and trailers; portable conveyors; coil winding lathes; wire coating machines; forging hammers — wherever there is an unusual job requiring utmost stamina with minimum attention. Write us for full details of Berry hydraulic pumps and motors.

## 5 reasons why Berry may be the answer to *your* power problem

- **Minimum loss of power through friction is obtained through use of free-floating rotating parts, plus rolling contact between high and low pressure areas.**
- **Instantaneous reversibility under load is possible because of the simplicity and symmetry of design and the small inertia mass in the rotating parts.**
- **High shock load capacity is achieved through generous design of component parts, plus monolithic mass of "stacked" plates. Sturdy piston design eliminates breakage, distortion or shearing.**
- **High starting torque is an outstanding characteristic since any unbalanced piston design forces rotation.**
- **Uninterrupted flow of power results in pulsationless smoothness of operation through the single-pass sweeping fluid channel, as interacting pistons *push* the liquid in a continuous manner.**

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**OLIVER IRON AND STEEL CORPORATION**
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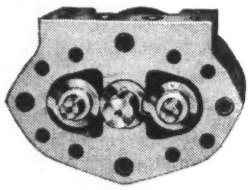

**HYDRAULIC PUMPS • MOTORS • CONTROLS • TRANSMISSIONS**

successfully reduced from 3 per cent down to 1 per cent with no loss of strength.

**Curtailed Copper:** The biggest sore spot in the whole materials program is copper, which promises to be the limiting factor in output of many civilian and some defense products. As one direct result, DPA has announced a 10 per cent cut in second-quarter production of consumer durables. Although only a small increase in copper supplies is forecast for 1952 many industry observers believe there are some grounds for optimism.

By the end of 1954, according to C. F. Kelley, Anaconda chairman, and J. J. Russell, chairman of Revere Copper and Brass, over 200,000 additional tons a year of mined copper should be available from both domestic and friendly foreign sources. This rate of increase is about the same as steel's projected expansion. However, the situation would be considerably eased, say producers, if price controls did not place so much of a restriction on imports. Domestic price is now 24.5 cents a pound; a Chilean quotation gives a price of 27.5 cents; and world market prices are 50 cents and higher. At the latter figure, U. S. mills cannot afford foreign copper; hence, copper imports have been low.

**Aluminum for Copper:** Many manufacturers have been urged by the government to substitute aluminum for copper where practicable, although present aluminum supplies are just as short. CMP requests for the present quarter were 167 per cent of supply for aluminum; about 154 per cent for copper. Thus it appears that metal-hungry manufacturers will have just as hard a time getting aluminum as copper—at least at present.

The picture for the near future, however, is entirely different. Domestic aluminum facilities are scheduled for almost a 50 per cent rise in productive capacity by the end of 1952, whereas copper's domestic increase will be about 14 per cent. Imports of aluminum from England and Canada are on the increase, while little relief is in sight for copper unless our competitive position on the world market changes. Aluminum may, accordingly, be the leading nonferrous metal by early 1953.

## Yes, Lockheed in California can train you – at full pay!

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**Note to Men with Families:** Housing conditions are excellent in the Los Angeles area. More than 35,000 rental units are available. Thousands of homes for ownership have been built since World War II. Huge tracts are under construction near Lockheed.

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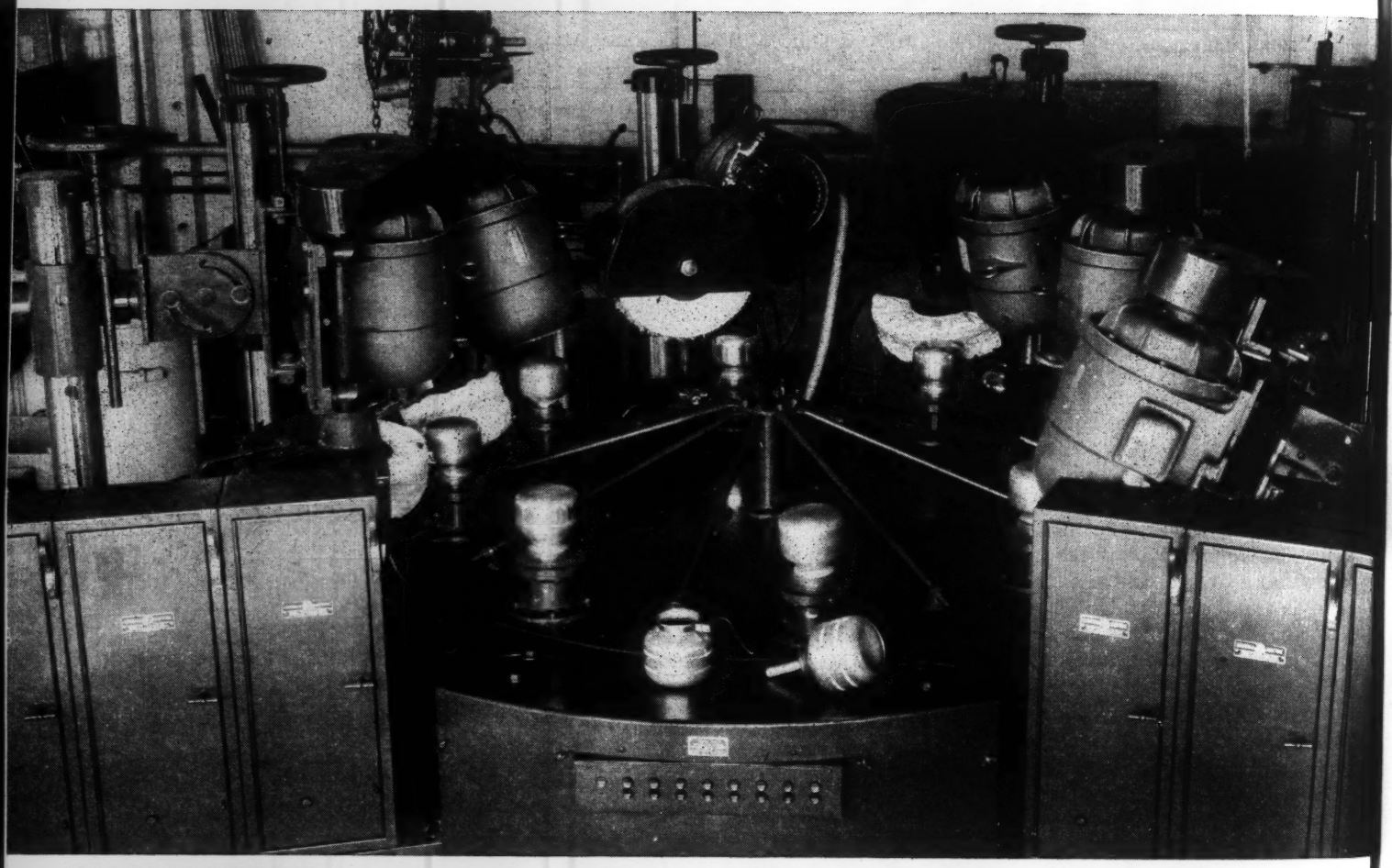
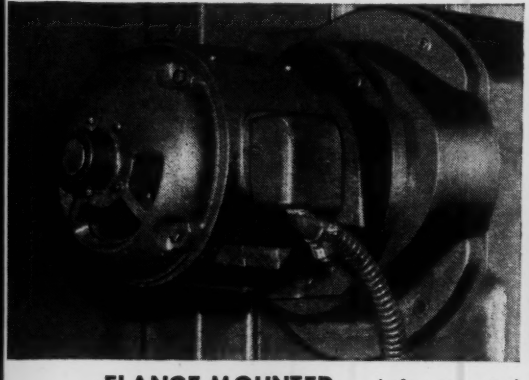
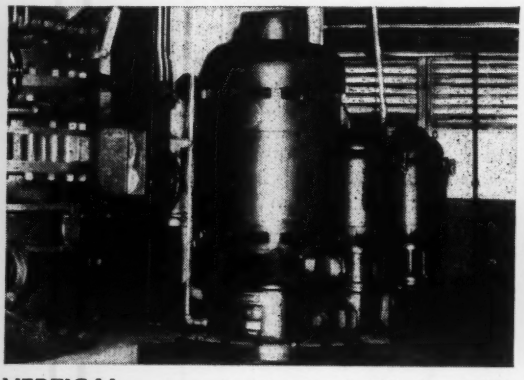
# DESIGNERS' PROBLEMS



**RIGOROUS OPERATION:** on continuous duty in various positions, these six standard 7½-hp totally-enclosed, fan-cooled Tri-Clad motors run machine which automatically polishes 500 to 1000 coffee-makers per hour! Rigid Tri-Clad motor construction permits mounting in any position, and the motor frame won't twist out of shape even if mounted on an uneven surface! Note how modern design of motors blend with machine appearance.



**FLANGE-MOUNTED** and face-mounted Tri-Clad motors are easily adapted to equipment designs to save space and improve machine appearance. As in all Tri-Clad motors, this one features completely enclosed bearings that last longer because they can be relubricated if necessary.



**VERTICAL** motor applications are simplified by NEMA standard type P bases used on both solid- and hollow-shaft Tri-Clad vertical motors. Above, Tri-Clad motors run circulating water and condensate pumps of large surface condenser.

**LOW-SPEED POWER,** compact design and dependability were design problems on this rotary-hearth billet conveyor—all solved with Tri-Clad gear-motors. Planetary gear system gives smooth operation, reduces mechanical losses to a minimum.

# GENERAL ELECTRIC

# SIMPLIFIED BY USING TRI-CLAD MOTORS

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Your problems in designing motorized products or installations are greatly simplified when you work with the G-E Tri-Clad motor line. Not only will you find the widest variety of types and ratings to fit your exact needs, but the flexibility and interchangeability of components are also to your advantage.

## EXTRA SERVICE

When you design a product with a Tri-Clad motor, you are assured of help from the largest staff of motor experts in the country.

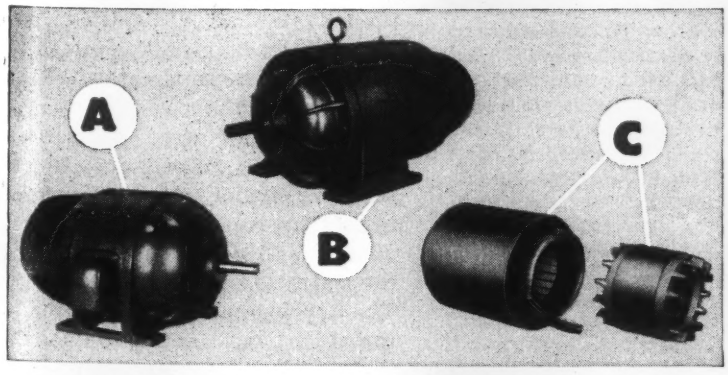
Moreover, the most complete service shop network in the motor industry backs up Tri-Clad motors on your products —another reason designers prefer Tri-Clad motors.

## EXTRA PROTECTION

*Every* Tri-Clad motor, open or totally-enclosed, is triply-protected against ***physical damage, electrical breakdown*** and ***operating wear and tear***—still another reason designers use Tri-Clad motors, not only on the usual jobs which they do so economically, but on the ***tough*** jobs where unfailing performance is a must.

## PROMPT DELIVERY

Especially important today, most models of Tri-Clad motors are available from stock at shipping points throughout the country. For more information send in the coupon below.

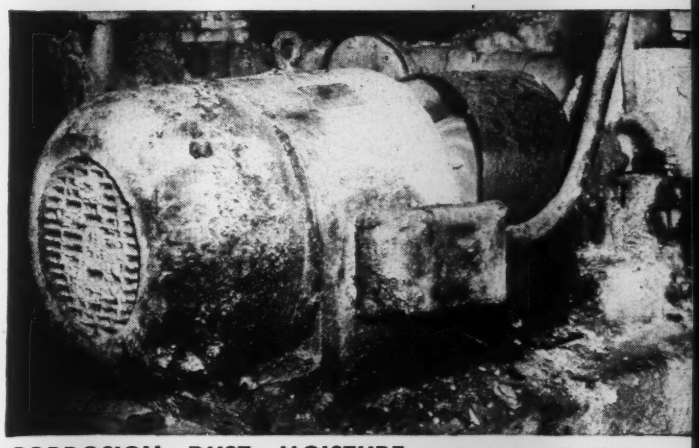



**THE WIDEST VARIETY** of standardized types and ratings in the motor industry are included in the Tri-Clad motor line. In addition to the examples shown in specific applications on these pages, here are a few other types which are used by designers everywhere:

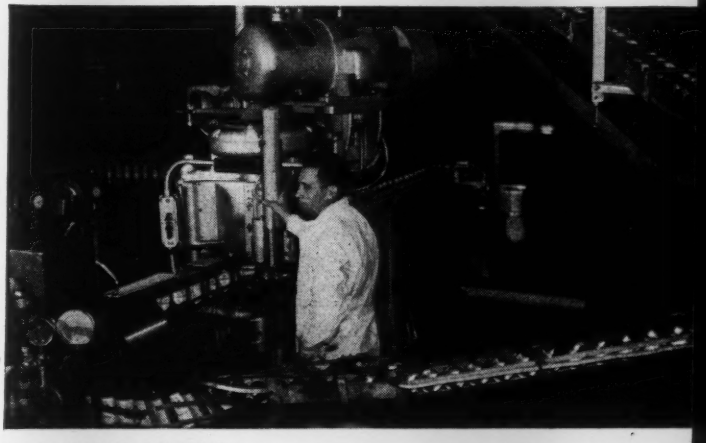
A **TRI-CLAD WOUND-ROTOR MOTOR** is used where extra-heavy starting ability is needed, and for adjustable-varying speed applications. Torque characteristics can be easily adjusted by changing external rotor resistance.

B **COMPACT TRI-CLAD BRAKE MOTOR** for use wherever you need an electrically operated spring-set brake. Equipped with Stearns magnetic brake. Most types of Tri-Clad motors are available with this brake.

C **G-E SHELL-TYPE MOTOR DESIGNED** for applications requiring a built-in motor. Especially suitable where compact, high-speed drive is required.



**CORROSION, DUST, MOISTURE** don't bother Tri-Clad totally-enclosed motors. This standard off-the-shelf 25-hp TEFC Tri-Clad motor runs pump 12 hours a day in soda ash crystallizing process in a chemical plant.



**VARYING SPEEDS** was one problem a designer had to solve in this can filling and sealing machine. The right solution was this 10-hp Type ACA Tri-Clad adjustable-speed a-c motor, rated 833 rpm to 2500 rpm. Speed can be adjusted by simply twisting a knob—at the motor or at a remote control station.

**SEND FOR INFORMATION**

General Electric Co., Section A752-13, Schenectady 5, N. Y.

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☐for reference only ☐for planning an immediate project

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☐GEA-4883 Tri-Clad ACA Adjustable-Speed Motors

☐GEA-3580 Tri-Clad Open Dripproof Motors

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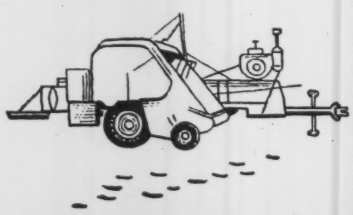

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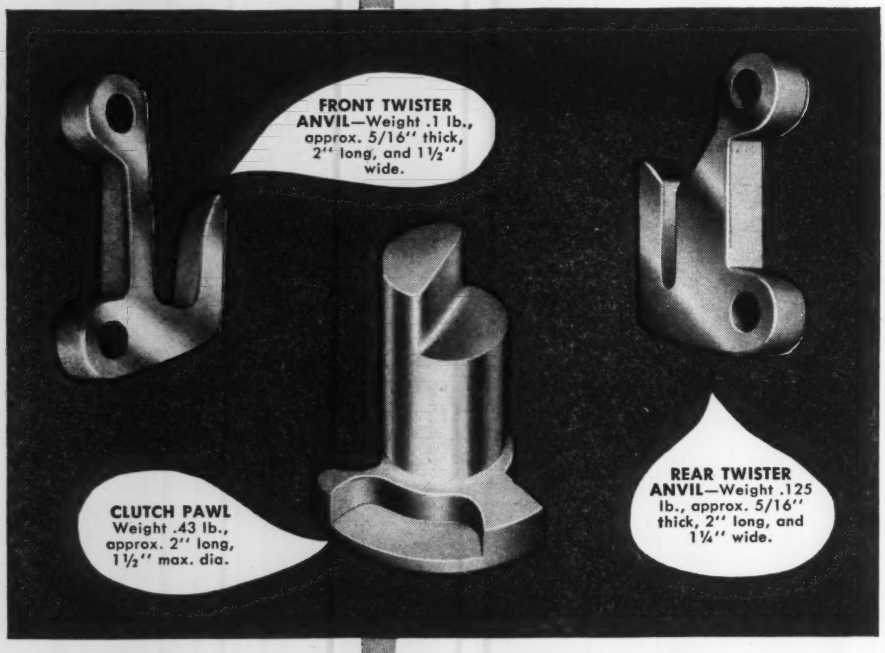


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# Design Abstracts

(*Continued from Page* 164)

prove the chances for recovery of parts of the rocket after impact. These operations consist of detonation of explosive charges located in the rocket in such a way that the rocket is severed into two or more unstable sections. Since the terminal velocity of the sections is considerably lower than that of the intact rocket, the chances for recovery of undamaged parts of the rockets are increased. This is particularly important in the case of research data that have been recorded upon photographic film.

Depending upon the effectiveness of the "blow-up" operation in slowing the descent of the rocket, the impact occurs 5 to 10 minutes after launching.

The external shape, *Fig.* 2, was determined almost exclusively by aerodynamic considerations. A body with a high slenderness ratio was picked to minimize drag, and four fins were added at the aft end of the body to provide aerodynamic stability.

### Steam Power Utilized

The vehicle was to be equipped with a liquid rocket power plant using liquid oxygen and alcohol as propellants and designed to generate a thrust at sea level of 20,000 lb for approximately 75 sec. Centrifugal pumps driven by a steam turbine were provided to deliver the propellants to the thrust cylinder at the necessary rate. The steam was produced by catalytic decomposition of high concentration hydrogen peroxide. The propellants were stored in tanks in the midsection of the rocket.

The design of the control system was determined by the necessity for this system to keep the vehicle stable without the aid of aerodynamic forces at launch when velocity was small and again at the end of powered flight when air density was essentially zero. This required that energy generated by the rocket be used in the form of reaction forces to produce the necessary controlling moments. A

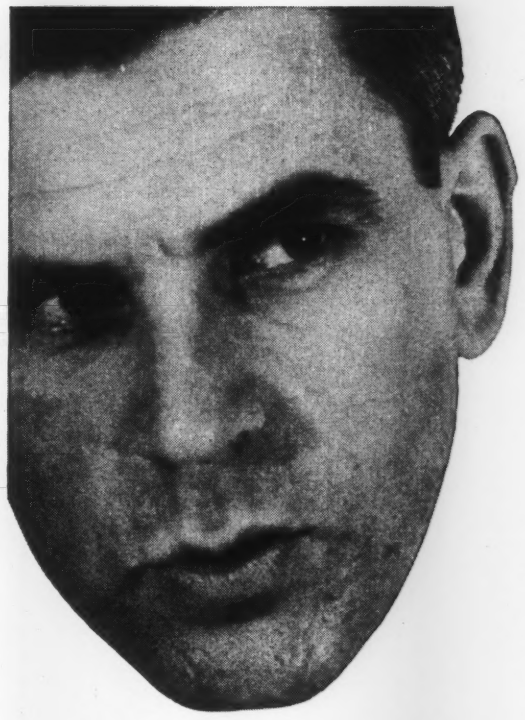
small part of the thrust energy was made available for control about the pitch and yaw axes by providing a means of deflecting the line of thrust with respect to the rocket's longitudinal axis. Rocket heading errors were detected by the gyros and the resulting signals, after passing through appropriate amplifier and derivative circuits, commanded the servos to operate to produce a thrust component normal to the rocket's axis of the proper magnitude and sense to correct the error in heading.

Similarly, roll-control moments were provided by ducting the exhaust steam from the turbine through an opposite pair of the fins to directable exhaust nozzles near the fin tips. In addition, controllable tabs were installed at the tips of the same two fins that contained the roll jets. The tabs provided additional roll-control moments during the period when disturbances from aerodynamic forces could be expected to be present.

### System Unbalance Compensated

It was probable that residual heading errors would be present at the beginning of coasting flight, since disturbances could be expected in connection with power plant shutdown that the main control system would not have time to correct. Changes in the direction of the thrust line during the shutdown transient and torques resulting from deceleration of the turbine were looked upon as the primary destabilizing forces at this point. Based on assumptions of the magnitude of these forces, it was determined that the pressurizing gas remaining in the storage sphere and propellant tanks contained sufficient energy to stabilize the rocket during the coasting period. Accordingly, small exhaust jets utilizing the pressurizing gas as a thrust medium were located to provide control about all three major axes as directed by the gyros.

Given a completed design, the greatest single factor influencing the performance of a rocket is the operating time of the power plant. For example, in the initial Viking design, a reduction of 5 per cent in power plant operating time causes a reduction in maximum altitude of approximately 25

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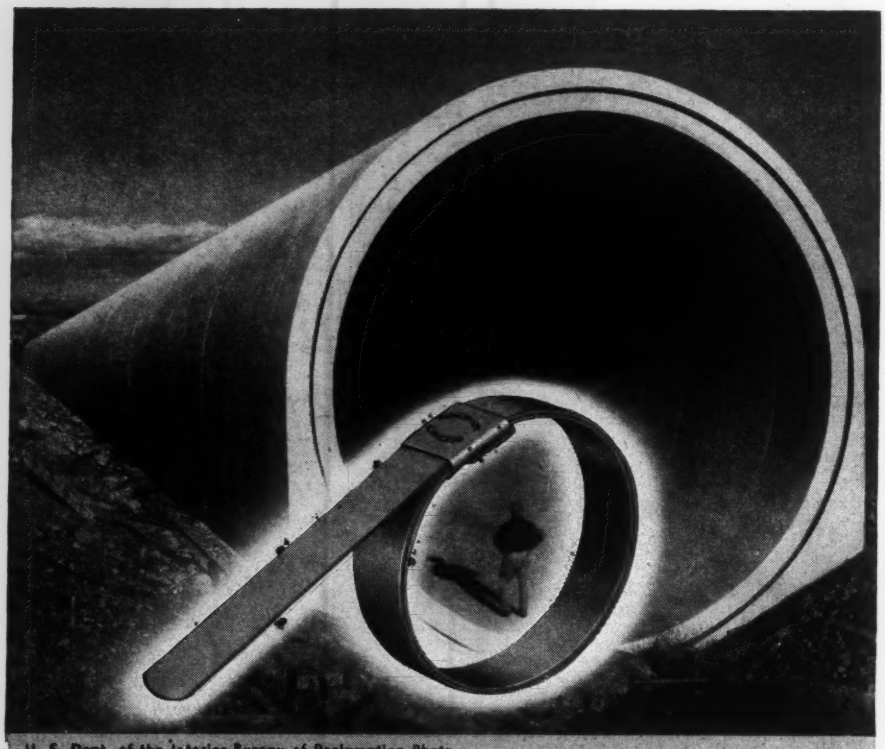

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Punch-Lok Hose Clamps were on the job in the construction of the giant Dry Coulee Siphon No. 1 of the Columbia Basin irrigation project in the state of Washington.

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per cent. To assure maximum usage of propellants, the power plant must operate at a mixture ratio during flight which will empty both tanks simultaneously. In opposition to this, the in-line configuration of the propellant tanks coupled with the increase in longitudinal acceleration causes enormous unbalances between the heads on the pump inlets. To provide some measure of regulation on the pump inlet heads, a controllable increment of pressure head was added to each propellant system in the form of regulated gas pressure. Since it was not practical to fully compensate all flight effects by this means, the remaining unbalance was minimized by designing the system for operation at the mean flight-mixture ratio.

Structural design of the Viking was, in general, straightforward. Standard aircraft techniques were applied, except in the case of the propellant tanks, which were called upon to perform the dual purpose of pressure vessel and primary structure. Aluminum alloys were used throughout, except for the skin on the fin leading edges and on the nose which was made of stainless steel in anticipation of high skin temperatures resulting from aerodynamic heating.

*From a paper entitled, "The Viking Rocket," presented at the I.A.S. Annual Summer Meeting in* 1951 (*Printed in full in the January,* 1952 *issue of Aeronautical Engineering Review*).

## Bending Clamped Sectorial Plates

By H. D. Conway and M. K. Huang

*Cornell University*
*Ithaca, New York*

BY USING two different methods of superposition on the elementary solution for a uniformly loaded circular plate with a clamped edge, the bending of a sectorial plate, clamped on all edges and subjected to uniformly distributed load, may be analyzed.

In the first method, a line distribution of loading in the form of a cosine series is applied normally to a diameter of the plate. Super-

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imposing this solution on that for a uniformly loaded plate, the unknown coefficients of the series are determined such that the resultant deflections of several points along the diameter under the line loading are made equal to zero. The maximum deflection and bending moment in a semicircular plate are thus found.

In the second method, a number of concentrated loads are applied normally to a diameter of the plate, the magnitudes of the loads being adjusted so that the resultant deflections at their points of application are zero. The resultant surface is then approximately the same as that for two semicircular plates having clamped edges and placed with their straight sides in contact. The method of superposition is then used to calculate the maximum deflection. The effect on the maximum deflection of varying the location of the concentrated loads is, within certain limits, quite small. The method, which may be used to analyze any sectorial plate, is then applied to the case of a quadrant of a circle, and the maximum deflection is again obtained.

*From a paper entitled, "The Bending of Uniformly Loaded Sectorial Plates With Clamped Edges," presented at the Annual ASME Meeting, November,* 1951.

## Gas Turbine Engine Materials

By R. H. Thielemann, J. C. Mertz and W. P. Eddy, Jr.

*Pratt & Whitney Aircraft Div.*
*United Aircraft Corp.*
*East Hartford, Conn.*

BECAUSE large amounts of critical alloying elements are required in the metals selected for mass production of turbojet and turboprop engines, a great deal of attention has been directed towards finding ways and means to conserve these elements. There are three possible methods of approach to each problem: (1) Development of more efficient manufacturing procedures so that parts can be made with minimum overall usage of critical materials, (2) substitution of protectively coated carbon or

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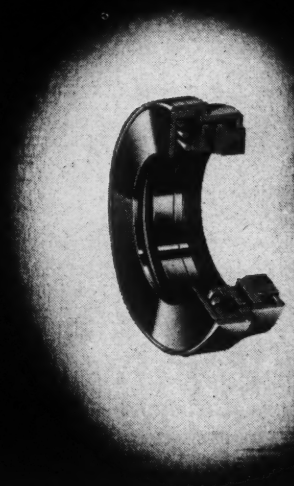

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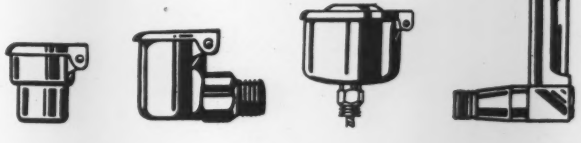

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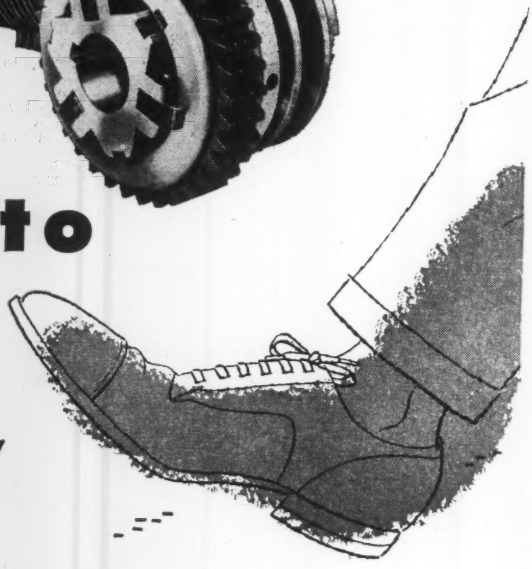

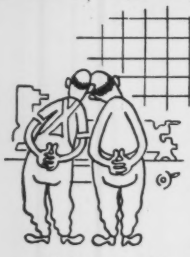

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***P.S.*** *Remember, too, that Twin Disc, world's leading industrial clutch manufacturer, is a pioneer in industrial* fluid drives *such as Hydraulic Couplings, Hydraulic Torque Converters, HYDRO-SHEAVES and HYDRO-WYNDS.*

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low-alloy steels for stainless alloys in parts which operate at relatively low temperatures, and (3) development of less critical super-alloys having high temperature properties equal or superior to those of existing alloys. Success in some applications of each of these methods may of course be impossible without redesign of engine components.

In general, if stresses are high and if temperatures encountered are much in excess of 1000 F, the austenitic chromium-nickel type alloys must be specified. For lower temperatures, choice between ferritic stainless steels and low-alloy steels is often dictated by creep values and requirements of corrosion resistance. Where the necessary corrosion resistance can be maintained under operating conditions by application of protective coatings, it is frequently possible to conserve appreciable quantities of chromium by specifying plain carbon or low-alloy steels.

### Coatings Aid Conservation

For nonrotating parts not subject to abrasion, such as brackets and internal supporting components, ample corrosion resistance is afforded by certain silicone-vehicle aluminum paints, provided temperatures do not exceed 400 or 500 F. Where abrasion and other mechanical abuse are factors, excellent corrosion resistance can be obtained by application of sprayed aluminum, provided the thick coating does not adversely affect performance and temperatures do not exceed approximately 600 F.

For protection of rotating parts where close dimensional tolerances must be maintained, cadmium plating can be successfully employed provided maximum operating temperatures are below the melting point of cadmium. The problem of protection of similar parts operating at temperatures above the melting point of cadmium is complicated by the fact that otherwise desirable metal plates, such as chromium and nickel, may seriously reduce the effective fatigue strength of the metal. Furthermore, it is virtually impossible to electroplate uniform thicknesses over surfaces of complicated parts. Because of relative uniformity of the deposited coating, electroless

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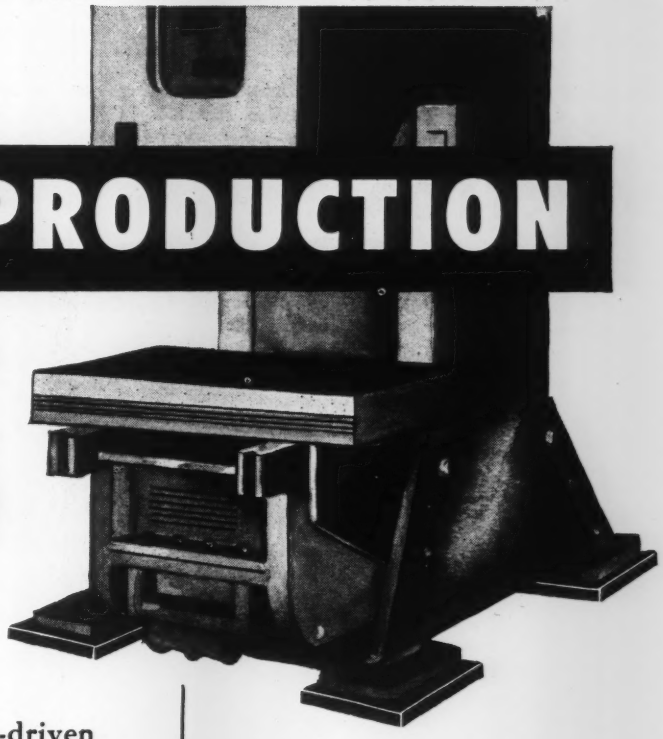

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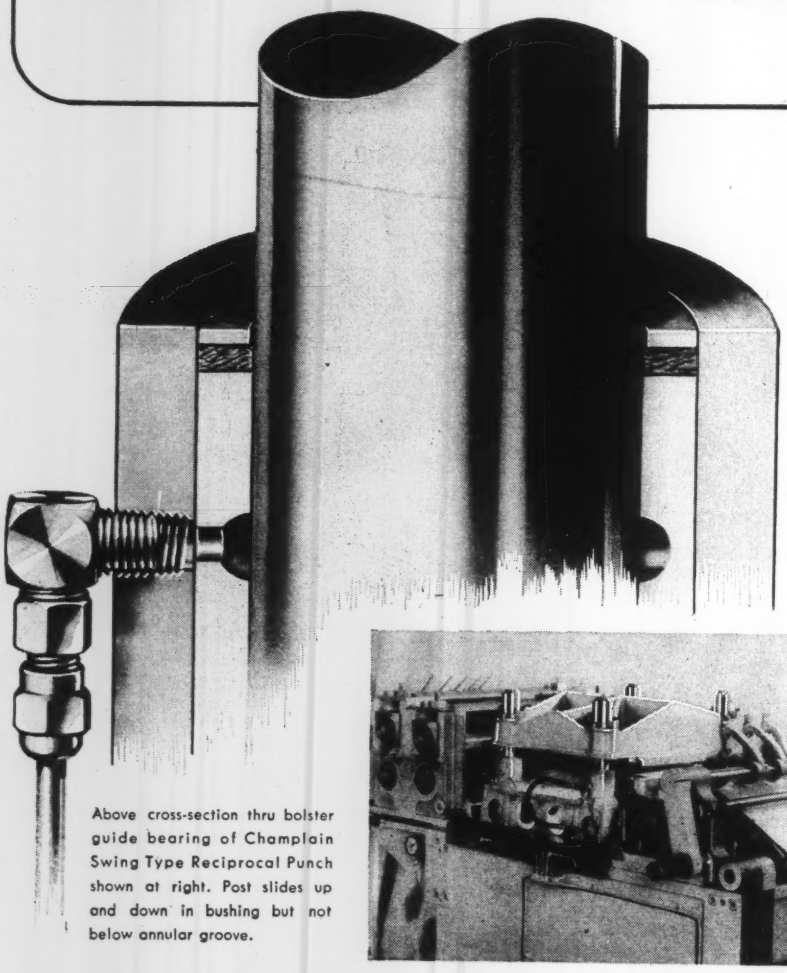
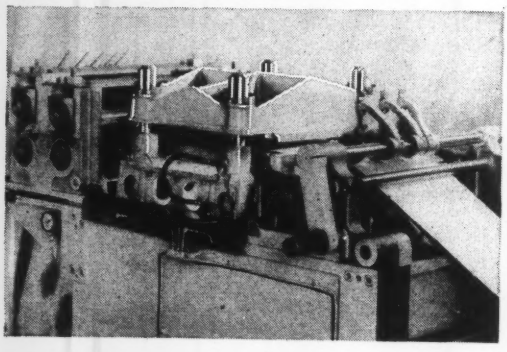


Above cross-section thru bolster guide bearing of Champlain Swing Type Reciprocal Punch shown at right. Post slides up and down in bushing but not below annular groove.



## ...the way CHAMPLAIN does it with a BIJUR SYSTEM

Keeping a constant oil film between the guide post and bushing was the problem here. It is solved by cutting an annular groove in the bushing . . . controlling the oil flow thru a meter-unit at the drilled passage . . . supplying a measured volume of oil from an automatic lubricator which force-feeds oil to all four guide posts and 47 other punch bearings. This is another example of Bijur "teamwork for bearing protection." For aid in solving your lubrication problems, call in a Bijur engineer.

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nickel plate holds considerable promise, although effects of this coating on fatigue endurance are not as yet known.

Where high resistance to corrosion, erosion, and abrasion must be maintained in parts which may operate at temperatures up to 1000 F, use of ferritic stainless steels seems mandatory. Such parts include axial-flow compressor blades, bolts, shafts, and turbine disks. For these applications, it appears that, in addition to the creep problem, consideration must be given to selecting the stainless grade least subject to stress-corrosion cracking.

Burner liners, transition ducts, and parts of exhaust tail cones in a turbine engine are subjected to gas temperatures ranging from 1200 to as high as 1800 F. Thermal stresses developed from high thermal gradients tend to produce buckling and eventual cracking. Materials which in sheet form have enjoyed the widest use for these parts are nickel-base alloys.

### Better Materials Needed

Turbine nozzle guide vanes are subjected to very severe temperature gradients. Because turbine performance is adversely affected if the nozzle throat area changes during operation, only alloys which have high creep strength at temperatures of 1600 F or higher can be considered. Since nozzle vane cross-sections are airfoils, it is desirable to make them hollow and of uniform wall thickness so that thermal stresses will be minimized. Because of their shapes, hollow nozzle guide vanes are difficult to fabricate from high-strength heat-resistant alloys. Therefore, precision investment castings are universally used, and cobalt-base alloys are specified. Properties of the best of these cobalt-base alloys are not all that is desired for the nozzle guide vane application. Material conservation would not be realized if several sets of replacement guide vanes made of a lower-alloy composition had to be furnished in place of one set of the present cobalt-base alloy vanes.

As far as turbine disks are concerned, the problem for the metallurgist has been to develop melting, forging and heat treating proce-

dures which will produce sound disks having uniform properties in all sections. Until reliable disk-cooling techniques are developed, so that temperatures at rims of turbine disks will not exceed 1000 F, use of ferritic steel turbine disks to conserve critical alloying elements will not be feasible. Requirements for turbine disks in current jet engines are that rims of disks shall have high load-carrying abilities up to temperatures of 1200 F and that room-temperature yield strength in hub sections of disks shall be not less than 75,000 psi. Reasonable ductility must be available in all sections of disks, so that stress concentrations resulting from design configurations or metallurgical defects can be relieved without cracking. For large turbine disks, the best solution to the problem seems to be the composite disk design in which a cold-worked austenitic alloy rim is welded to a heat treatable low alloy steel hub. By this construction, desirable properties of each type of material are efficiently utilized and appreciable savings in critical alloys are realized. However, if cost of production, overall use of critical materials and the weld wire are taken into account, the one-piece austenitic alloy disk forging appears more attractive for disks smaller than 18 or 20 inches in diameter.

### New Alloys Hold Promise

For the one-piece austenitic alloy disk forging, desire for an alloy in which needed properties could be developed by heat treatment instead of by cold-working has always existed. Advantages of such an alloy are that properties would be easier to control and the large forging equipment now needed to do cold-working would not be necessary. In recent years, two similar alloys of the titanium-bearing precipitation-hardening type have been developed. Turbine disks of both alloys have been fully tested in engines with generally excellent results. Both alloys have properties which make them attractive also for applications other than turbine disks, such as bolts, flanges and turbine blades which run at temperatures under 1100 F.

Turbine blade requirements for


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Technical Service Data Sheet

Subject: PROTECTING FRICTION SURFACES WITH THERMOIL GRANODINE®

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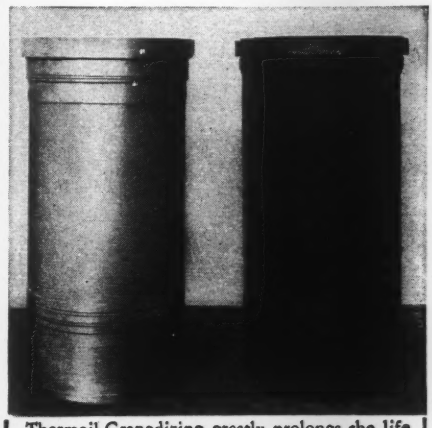
Fabricators and product designers, particularly in the automotive field, are aware that even highly polished surfaces under friction weld, gall and score. One of the most inexpensive and practical methods of preventing this is to coat the metal to prevent metal-to-metal contact. With cast iron or steel, the "Thermoil-Granodine" manganese-iron phosphate coating provides a wear-resistant layer of unusual effectiveness.



Thermoil-Granodizing greatly prolongs the life of parts subject to friction. It protects the surface of products like the diesel engine liners shown above and the many moving parts of automobiles and other machines. "Thermoil-Granodine" with its remarkable lubricating properties is particularly valuable in these and similar applications because of its ability to retain oil and maintain lubrication under high pressures and high velocities. This ACP wear-proofing chemical not only permits rapid break-in without scoring, scuffing and welding but also reduces subsequent wear on friction parts.

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|---|---|
| MIL-C-16232 Type I | Coatings — phosphate; oiled, slushed, or waxed (for ferrous metal surfaces) and phosphate treating compounds. |
| AN-F-20 (See also U.S.A. 3-213) | Finishes, for electronic equipment. |
| U.S.A. 57-0-2C Type II, Class A | Finishes, protective, for iron and steel parts. |
| U.S.A. 51-70-1 Finish 22.02, Class A | Painting and finishing of fire control instruments; general specification for |
| M-364 | Navy aeronautical process specification for compound phosphate rust-proofing process. |

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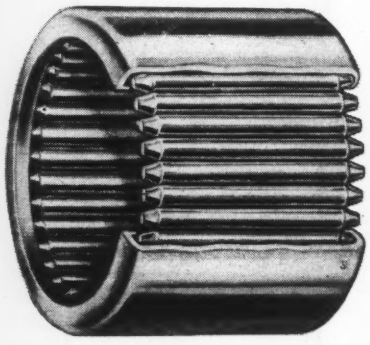

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a modern high-thrust turbojet engine are for a material with high load-carrying ability at temperatures of 1500 F and higher. Two cobalt-base alloys have been developed which appear to meet these requirements. Since both alloys contain large proportions of critical alloying elements, their continued use for turbine engine blading in a greatly expanded jet engine program might well be a limiting factor with respect to the number of jet engines produced.

*From a paper entitled, "Trends in Gas Turbine Engine Materials," presented at the SAE Annual Meeting in* 1952.

## *Impact Extrusion of Magnesium*

By T. L. Patton

*Process Development Div.*
*Dow Chemical Co.*
*Midland, Mich.*

IMPACT extrusion is a unique process for making small symmetrically shaped tubular parts. The part is made by placing a disk or slug of metal of the required volume into a die cavity and applying pressure with a punch. The pressure forces the metal to flow or squirt up around the punch, the clearance between the punch and die determining the wall thickness of the part.

Some of the advantages of the impact extrusion process for making deep formed parts over other processes such as drawing are:

1. Tooling is relatively cheap
2. Production rates are high.
3. Parts may be made in one step as compared with several required on the same part made by deep drawing.
4. The bottom thickness of a part may vary within wide limits while keeping the wall thickness constant
5. Ribs, flanges, bosses, etc., may be incorporated in the part

The impact extrusion process has been used to make a variety of parts; however, the majority of magnesium parts made up to this time have been of the sizes and shape used in the dry cell battery industry. The process for mag-

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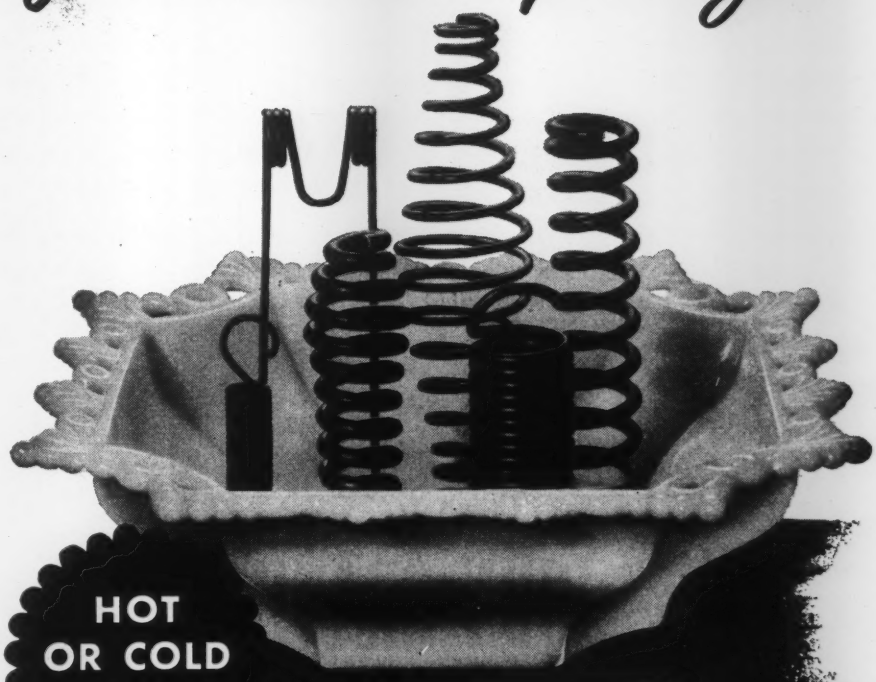

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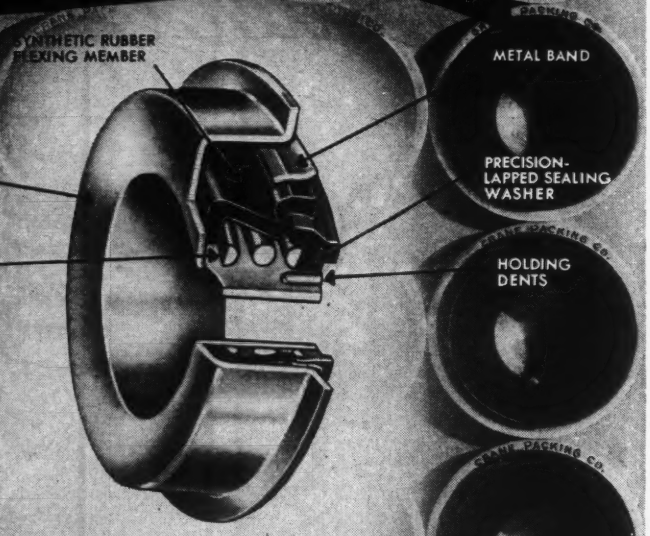


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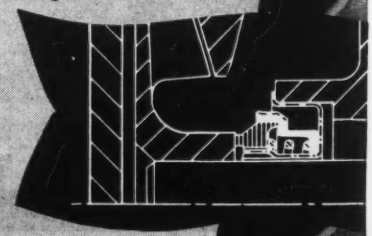

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nesium impact extrusions is basically the same as for other metals, the main difference being the temperature of operation which in the case of magnesium alloys may vary from 350 to 700 F depending on the alloy used, the speed of operation, and the size of the part.

Some of the advantages of magnesium worthy of consideration for impact extrusion applications are the lightness of parts, the rigidity of parts which allows them to be rough handled right from the extrusion press without damage, excellent resistance to many organic chemicals, oils, and alkaline solutions, and excellent electrical conductivity.

The magnesium impact extrusion process consists of four operations: (1) Slug preparation, (2) impact extrusion operation, (3) trimming operation, and (4) cleaning operation.

### Temperature Affects Process

Presses of the horizontal or vertical, mechanical or hydraulic types may be used for the impact extrusion operation. Close tolerances may be held by careful alignment of tools, short punches, perfect alignment of the press ram, low clearances between slug and die, and proper slug lubrication. Plus or minus 10 per cent of the nominal wall thickness is considered a good production tolerance. The bottom thickness tolerance is usually plus or minus 0.005-in. In starting up with a cold punch the expansion of the punch due to heating must be considered in holding this tolerance. When operating on a hand feed basis (10 to 15 parts per minute), the slugs and the die shoe are heated to 500 F. The only heat applied to the punch is that picked up during the operation. Optimum temperature for continuous operation has not been determined, but it is somewhat lower than 500 F, since the die will take on some heat due to the working of the metal. Under some conditions the die temperature has been as low as 350 F. The size of the slug and finished part must also be considered in arriving at the optimum temperature.

The pressure required for magnesium impact extrusions varies with temperature, reduction in

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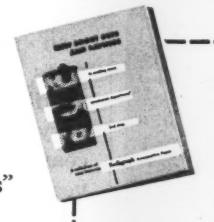

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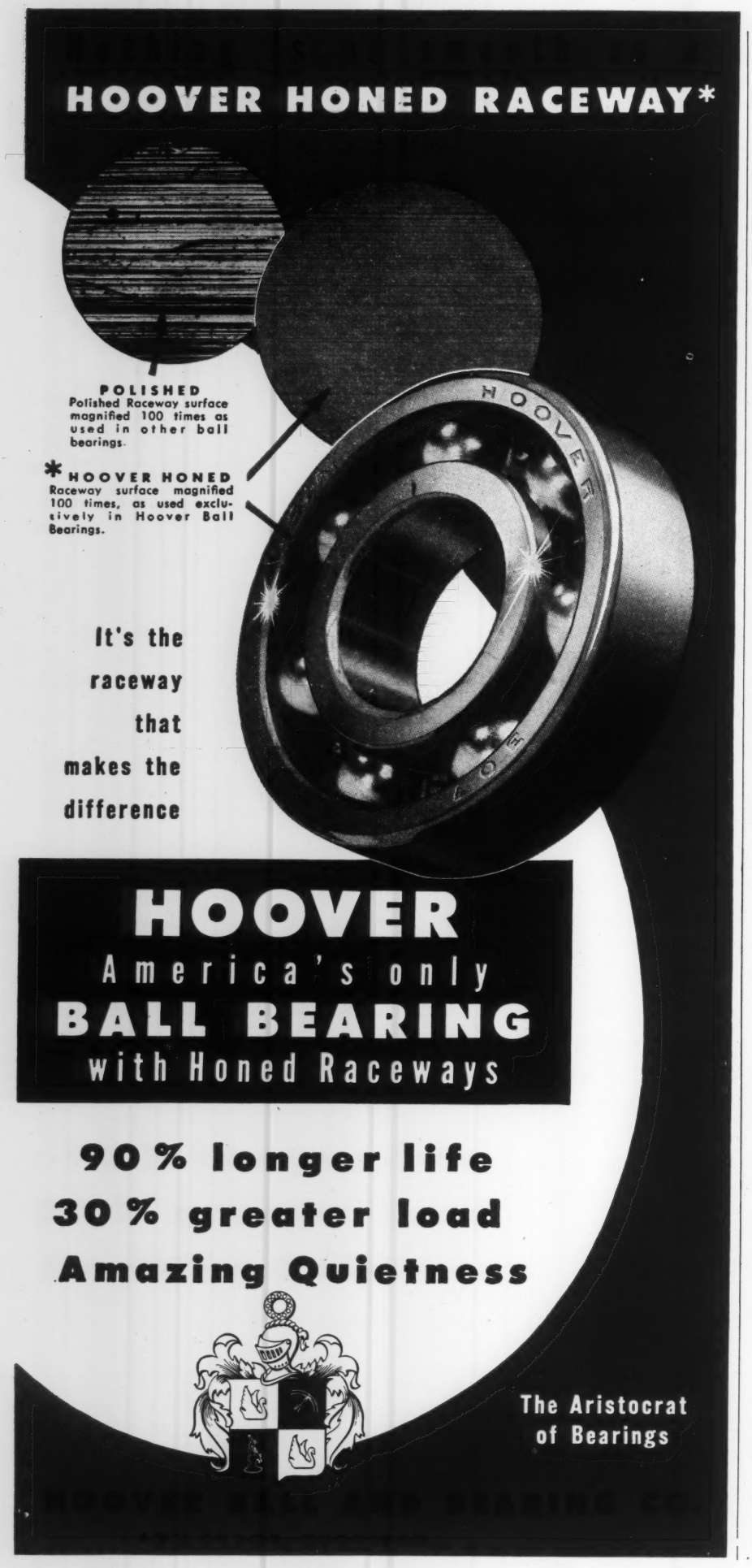



area of part, alloy, and lubricant used. The pressure drops considerably as the operating temperature is increased to 700 F, but the tendency for die loading and scoring of parts increases. The pressure does not change considerably for reductions in area below 85 per cent, but above this amount, especially above reductions in the area of 90 per cent, the pressure increases rapidly. There are indications that the lubricant used may cause a variation in the load required although this has not yet been studied in detail. The shape of the slug may also cause some variations in load.

The main problem in the impact extrusion process is to make products having uniform wall thickness and good quality. The factors which can affect the eccentricity of the part are: (1) Poor alignment of tools, (2) nonuniform lubrication, (3) improper or insufficient backing of tools, (4) bending of the punch because of improper material, heat treatments, or slenderness ratio, (5) size of slug used, and (6) a poorly guided press ram.

*From a paper of the same title presented at the 7th Annual Meeting of The Magnesium Association.*

## *Inelastic Strains in Steel Beams*


By H. T. Corten, M. E. Clark and O. M. Sidebottom

*University of Illinois*
*Urbana, Ill.*


INELASTIC deformation in metals is known to be a time-dependent phenomenon; however, the theoretical relations between load and deformation do not, in general, include the effect of time. Most of the experimental data, confirming these theoretical relations, have been obtained using screw-powered or hydraulic testing machines in which the load "falls off" as inelastic deformation occurs. Furthermore, these tests have been made without regard to the length of time necessary for inelastic deformation to cease at any given load. This investigation was undertaken to determine the effect of testing members under dead load where each

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increment of load could be maintained on the member a sufficient length of time until equilibrium was attained. Five statically determinate beams, four mild-steel beams of various cross sections and one rail-steel rectangular beam, were tested in a dead-load testing machine.

For all beams tested, regardless of the shape of cross section or type of steel, the experimental moment-strain or moment-deflection diagrams were not found to be continuous as is usually reported. The diagrams were found to have a stairstep appearance.

Each of the experimental curves for all of the mild-steel beams fell considerably below the theoretical curves for large inelastic strains. In contrast, the experimental points for the rail-steel beam were found to lie either on the theoretical curves or slightly above them. The rail-steel beam, which strain-hardened throughout the inelastic range, did not exhibit a fully plastic moment since any additional strain resulted in an increase in resisting moment. This is in agreement with the theoretical moment-strain and moment-deflection relations.

### Tests Reveal Peculiarities

The fact that the experimental data for the mild-steel and rail-steel beams fall below and above the theoretical curves, respectively, can be attributed to the different types of inelastic deformation exhibited by the two steels. As is well known, the inelastic deformation in mild-steel members is very nonhomogeneous. However, the rail-steel material strain hardens even for small inelastic strains so that the deformation is reasonably homogeneous.

Another of the peculiarities of dead-load testing is the time delay required for the initiation of inelastic deformation at a given load. This was observed particularly in the mild-steel beam tests. If the beam was allowed to reach a state of static equilibrium at any load which has produced inelastic deformation, a small increment of load was not found to initiate inelastic deformation until after an appreciable time delay. This time delay of inelastic deformation in

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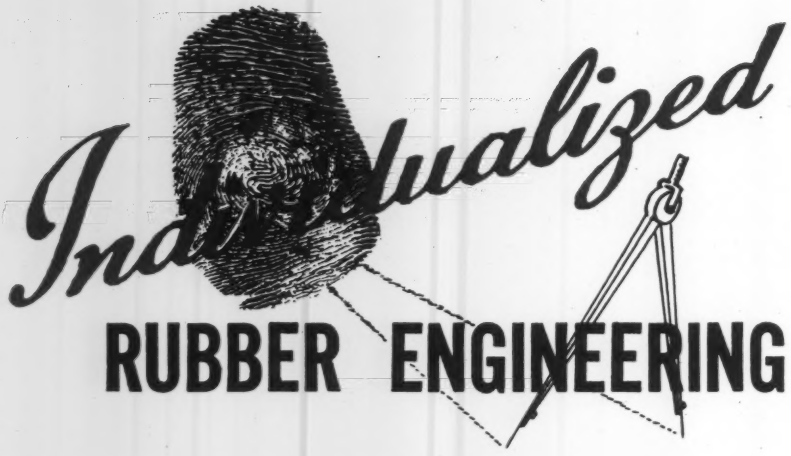

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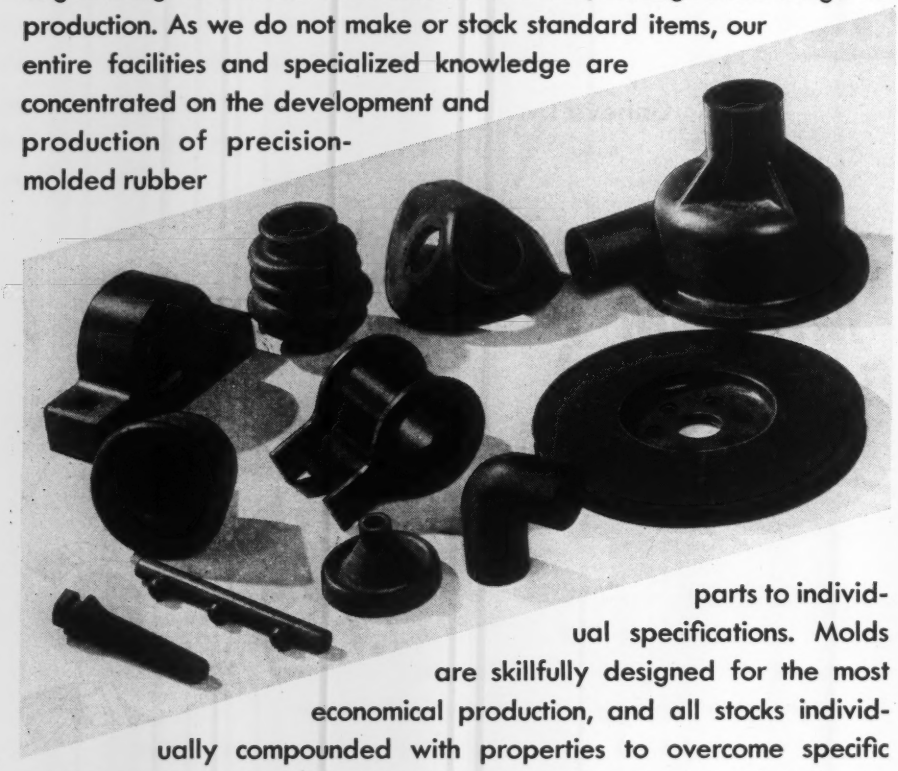

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mild-steel beams also depends upon the magnitude of the increase in stress caused by the increment of load. The time delay has been observed for increases in stress of 1000 to 1800 psi, while other tests indicate that the time delay was eliminated when the increase in stress was 3000 psi.

For the rail-steel beam there were no indications of time delay for initiation of yielding. However, the time required to reach static equilibrium was approximately the same as for the mild-steel beams.

In general, the load-deformation behavior of the rail-steel material was found to be more stable than the mild-steel material when subjected to dead loads which produced inelastic strains up to 10 to 15 times yield strain.

The behavior which was typical of the three different mild steels that were investigated may be expected to occur in service applications where the load is essentially constant and large enough to produce inelastic deformation. The phenomenon may explain the loosening of shrink fits and other peculiarities which occur in steel members and should be considered in the formulation of more rational procedures for the design of structural elements.

*From a paper entitled, "Peculiar Behavior of Steel Beams Under Dead Loads That Produce Inelastic Strains," presented at the ASME Fall Meeting of* 1951.

## Automatic Transmissions


By O. K. Kelley

*General Motors Corp.*
*Detroit, Mich.*


ANALYSIS of the struggles and the successes of automatic transmission engineers in this country reveals that of the many possible ways of accomplishing a variable-ratio drive only two have proved practical. They are the Hydra-Matic principle and the hydrodynamic principle.

The Hydra-Matic principle drives through efficient planetary gears and controls transmission ratios by using simultaneously acting friction elements or free-wheelers and friction elements to transfer the drive from one ratio to the other

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American can fill your orders, large or small, for either roll felt or felt parts cut to your specifications.

Sales Offices are maintained by American in all sections of the country. Get in touch with the one nearest you. You will receive immediate attention, and delivery will be rapid.

And remember that the Engineering and Research Laboratories at Glenville are ready to collaborate with you on such matters as the selection and specification of felt and new allied products to meet your specific needs.

For all the felt you need—call American!

**American Felt Company**

TRADE MARK

GENERAL OFFICES:
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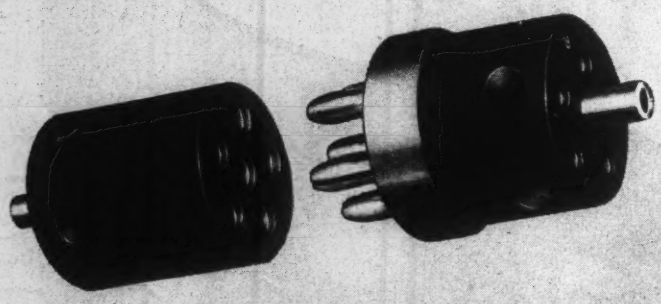
SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, San Diego, Montreal—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

where HARD RUBBER is right...
use it!

how to
SIMPLIFY DESIGNS

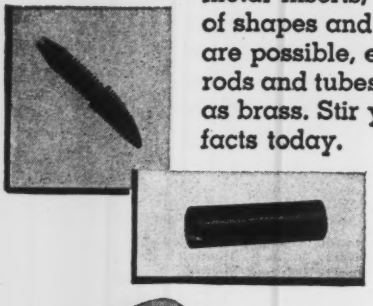


6-HOLE
ELECTRICAL
CONNECTOR

with
ACE®
extruded hard rubber

SAVES
MACHINING
MOLD COSTS

Just conjure up the right hard rubber extruded shape, and the job of making many a small part is half done! The electrical connector above, for example. For good electrical properties, stability and strength, it's made of ACE hard rubber rod with the six holes extruded right in it. Simply cut it off to length, soften by heating, press in the metal inserts, and presto! An amazing variety of shapes and compounds of ACE Hard Rubber are possible, even extruded directly over metal rods and tubes. Machines and finishes as easily as brass. Stir your imagination? Write for more facts today.



Keep your ACE Hard Rubber and Plastics Handbook handy. Free on request. It's a gold mine of hints like these.

American Hard Rubber Company

93 WORTH STREET · NEW YORK 13, N. Y.

without interruption of power while changing ratios. This principle can be used to build up a transmission of any ratio coverage. The number of planetary gears and friction elements required is dependent on the total ratio coverage and the degree of elimination of "performance holes" between the shifts. Control of the shifts is accomplished by hydraulic power application of the friction elements and can be made automatic, semi-automatic or entirely manual. There are important applications of this principle in all automatic transmissions for passenger cars, military vehicles and tractors.

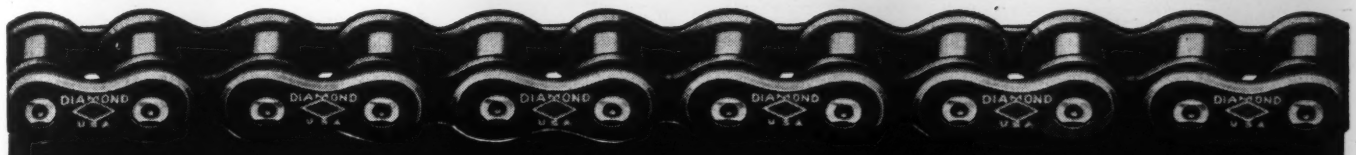
### Coupling Damps Vibrations

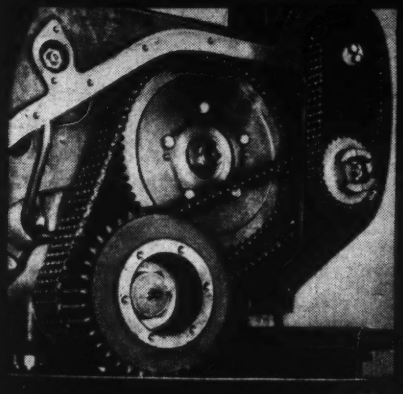
The hydrodynamic principle transmits torque by changing the rotating momentum of a mass of oil. In the two well known examples of this principle, fluid couplings and torque converters, there is an engine-driven centrifugal pump which gets the oil spinning and forces it into a turbine connected to the driving wheels. The turbine absorbs the spinning momentum and drives the vehicle.

The fluid coupling is not a torque multiplier, requiring gears to produce different drive ratios. Its value lies in its simplicity and high normal drive efficiency, combined with an excellent ability to pick up a load from standstill smoothly and automatically. It is the most practical smooth, automatic starting clutch with almost unlimited life without wear and readjustments, and it has considerable value in its inherent characteristic of stopping the transmission of torsional vibrations.

The torque converter, as the name implies, is a variable-torque ratio hydrodynamic drive. It is more complicated in design than the fluid coupling as it has to use additional bladed members to regenerate the turbine discharge velocity into additional forward drive momentum which adds torque to the pump, thus producing a more powerful spinning momentum out of the pump than what the engine alone could produce (a sort of a boot-strap lifting). The degree of torque multiplication depends on the amount of this regeneration, which in reality is merely an arti-

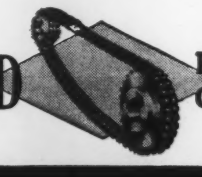
# You Can Do It Better With
# DIAMOND ROLLER CHAINS



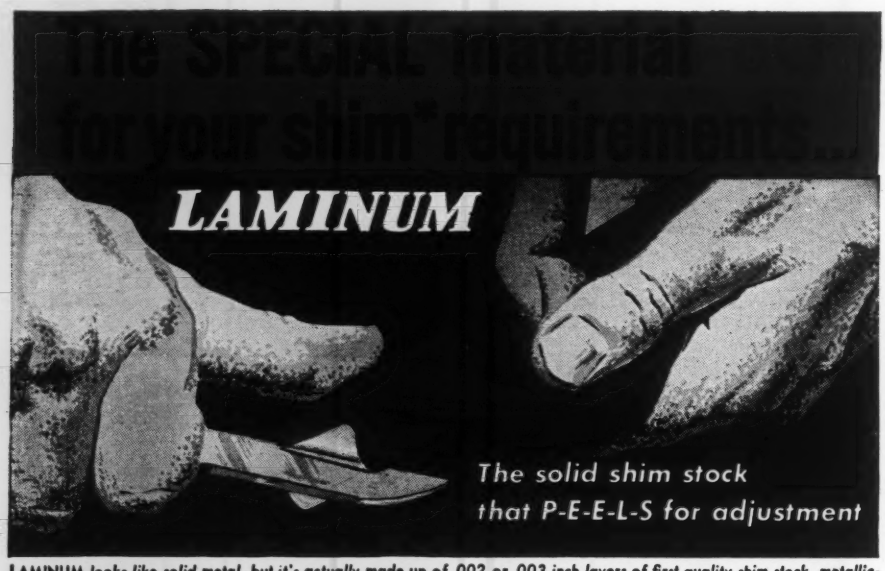


● The Diamond engineering staff is well experienced in recommending drive selections to meet all requirements. Special precision manufacturing facilities and skill insure uniformity of quality and great reserve strength required for long-life performance. *Practical recommendations are yours for the asking.*

**DIAMOND CHAIN COMPANY, Inc.**
Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana
*Offices and Distributors in All Principal Cities*



**DIAMOND ROLLER CHAINS**




*LAMINUM looks like solid metal, but it's actually made up of .002 or .003 inch layers of first quality shim stock, metallically bonded together. Peels easily with a penknife.*

LAMINUM, the metal that peels, comes in a wide range of thicknesses and laminations. Here is the basic information on this versatile, money-saving material.

**STANDARD STOCK 8" x 48" SHEETS**
**BRASS AND STEEL**

| Gauge | .002 inch laminations | .003 inch laminations |
|---|---|---|
| .006 | x | |
| .008 | x | |
| .010 | x | x |
| .016 | x | x |
| .020 | x | x |
| .032 | x | x |
| .048 | x | x |
| .062 | x† | x† |
| .094†† | x† | x† |
| .126†† | x† | x† |

†Also available as half laminated brass and half solid brass.
††Available in brass only.

**PROPERTIES & SPECIFICATIONS**

**BRASS** – Raw material is a commercial half hard high brass conforming to Federal Spec. QQ-B-611a, Comp C, half hard (5/27/44). The *laminated* brass conforms to Navy Aeronautical Spec. S-122, Aeronautical Material Spec. AMS-4508, Navy Ordnance Spec. 47B6.

**STEEL** – The raw steel used in LAMINUM conforms to Federal Spec. QQ-S-636, Condition 2, as well as SAE-1010. There are no government specifications on the finished steel LAMINUM.

Normally all LAMINUM stampings are made by us to our customers' specifications. However, for repair and maintenance work, some of our standard stock is available from your industrial distributor.

**SHIM SIZE IS VIRTUALLY UNLIMITED**

We've made some shims as large as 102 inches across—and others as small as your fingernail. With special joints developed over the years, we can make any size LAMINUM shim you want.

Other than standard thicknesses and lamination arrangements can be supplied upon special order.

**BABBITTED SHIMS PREVENT OIL PRESSURE LOSS**

Shims for use in split bearings can be fitted with babbitt lugs to prevent oil pressure loss without shaft scoring.

**LET OUR ENGINEERS HELP YOU . . .** We've been designing shims for 37 years. Why not throw that problem of yours at us? There's no obligation, of course.

SEND TODAY
FOR OUR ENGINEERING DATA FILE with all the quick facts on LAMINUM plus a free sample for your inspection.

***LAMINUM is used primarily for shims. But these facts may spark other thoughts that we'd be happy to help you develop.**

**LAMINATED SHIM COMPANY, INC.**
1203 UNION STREET GLENBROOK, CONN.

CUSTOM SHIMS

STAMPINGS

SHIM STOCK

AN·COR·LOX NUTS


ficially increased flow velocity. Increased flow velocity naturally exerts more force on the turbine blades but it also means more flow friction and turbulence losses. This sets definite limitations on the torque converter, which can be generalized by saying: the higher the torque multiplications, the lower the efficiency. When the turbine speed in the torque converter begins to approach the pump speed, the discharge velocity from the turbine is no longer capable of being regenerated into a boost torque for the pump. The pump and the turbine become, in effect, a fluid coupling. But here it is important to note that if the pump and the turbine and the regenerating members are designed for high torque multiplication, they are far from being properly shaped for an efficient fluid coupling.

The infinitely variable smooth operation with substantial torque multiplication at low speeds, decreasing as the speed increases, is, however, a very valuable asset in an automatic transmission. Every postwar design of automatic transmissions has made use of the torque converter in spite of its limitations.

### Combination Is Best

Using a combination of the torque converter with Hydra-Matic type gear-ratio mechanism, there is a clear opportunity to accomplish more than the torque converter alone can do. This is just what has been done in most postwar passenger car transmissions, all cross-country military transmissions and tractor transmissions. In some designs a torque converter is used as a mild torque-multiplier fluid-coupling combination. In others it has been used as a stronger torque multiplier and locked out entirely for one to one torque ratio driving by clutching the input member to the output member. In most cases it has been combined with Hydra-Matic type gearing of one or more steps. This combination has produced many commercially successful transmissions.

*From a paper entitled, "Automatic and Hydraulic Transmissions," presented at the SAE National Transportation Meeting in* 1951.

# News
## OF MANUFACTURERS

LOCATED at Lehigh and Main Sts. in Morton Grove, Ill., the new plant of the **Janette Mfg. Co.** was opened recently. This plant provides 100,000 sq ft of floor space and will house company executive offices and complete production facilities. These facilities have been expanded with the addition of new machine tools and other precision equipment.

♦

Twelve acres of land located at Knowland Rd. and 35th St., Independence, Mo., were purchased recently by the Tractor Division of **Allis-Chalmers Mfg. Co.,** Milwaukee. Plans have been made for the immediate construction of a new factory branch to serve agricultural and industrial dealers in eastern Kansas and western Missouri.

♦

**De Laval Steam Turbine Co.,** Trenton, N. J., has announced the formation of a subsidiary corporation, the **De Laval Turbine Pacific Co.** Headquarters of the subsidiary will be in a new building located at Main and Folsom Sts., San Francisco, Calif.

♦

A 13,200-ton extrusion press is being installed at the Lafayette, Ind., works of the **Aluminum Co. of America,** Pittsburgh. Leased from the U. S. Air Force, the new press will make possible the production of larger, lighter, more intricate extruded aluminum shapes for aircraft and other industries.

♦

On April 1, **Clippard Instrument Laboratory Inc.,** Cincinnati, will move to a new plant now being constructed at 7350-7390 Colerain Ave., between Mt. Airy and Groesbeck, O.

♦

The U. S. Air Force has awarded a contract to **Reynolds Metals Co.,** Louisville, Ky., involving the construction of a new building at its Phoenix, Ariz., plant and the in-

(*Continued on Page* 242)

S.S.White
**FLEXIBLE SHAFTS**
***retain their smooth operating characteristics!***

**HERE'S what Barber - Colman Company of Rockford, Illinois says about the S.S.White flexible shaft used in their Remote Adjustable Thermostat unit shown above:**

*"Test results indicate that the operation of the S.S.White remote control flexible shaft is satisfactory at temperatures ranging from −65°F. to +160°F. There is virtually no measurable variation in torque required to turn the shaft, or in torsional deflection required to initiate cam movement over the temperature range."*

**The reason—S.S.White flexible shafts of both power drive and remote types are subjected to exhaustive tests in S.S.White research laboratories to assure premium performance under every type of operating condition.**

**SEND FOR THIS 256-PAGE FLEXIBLE SHAFT HANDBOOK**

***Complete, authoritative information on flexible shaft construction, selection and application. Copy sent free if you write us direct on your business letterhead, giving your title. There's no obligation.***

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. 4, 10 East 40th St.
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

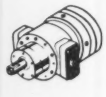
# Denison scores

## A Few Denison FIRSTS

**1944** Multipress . . . self-contained oil hydraulic production tool offering a new concept of wide-range adaptability and control.

**1946** 5000 psi relief, sequence and unloader valves. Hydraulically balanced . . . closer control.

5000 psi constant volume pumps . . . heavy duty, high volumetric efficiency.



**1948** 5000 psi variable-volume pumps for handwheel, cylinder, stem or pressure compensator control of pump volume.

**1950** 5000 psi surge-damping controls in both aircraft and industrial models.

5000 psi pilot-operated directional controls . . . positive action regardless of pressure.

THREE popular sizes . . . Built for 2000 psi continuous duty . . . Ready for use as either pump or motor without alterations of any kind in the unit itself . . . Clockwise or counter-clockwise operation as either pump or motor . . . 5 to 60 gpm pumping capacities . . . 380 to 4600 inch-pounds torque capacities as a motor . . . Hydraulically balanced vane action, with dual sealing edges contacting cam ring . . . Meets 16 different porting and directional requirements as either pump or motor . . . Face, flange and foot mountings . . . Rugged, space-saving compactness plus two-way efficiency!

**DENISON** TRADE MARK *HydrOILics*

# another FIRST

# NOW a single-stage 2000 psi

## Dual Purpose Vane-Type Oil Hydraulic Pump

*"The Finest Money Can Buy!"*

Denison adds another important *first* to a long list of new and improved products and ideas in the oil-hydraulic field. This all-new, radially balanced hydraulic power unit works equally well as a pump or as a fluid motor! No changes of any kind have to be made in the unit itself. *Think of the advantages in being able to stock one type of unit for both pump and motor needs!*

In addition the new unit offers either clockwise or counter-clockwise rotation—for either pump or motor applications.

The unit is built in three sizes, each offering interchangeable cam rings for various volume or torque requirements — providing eight different pump or motor capacities in all.

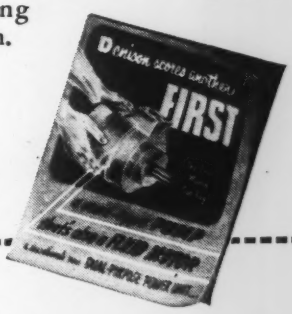
*As a pump* — the 8 models have volume capacities from 5 to 60 gpm and are capable of operating continuously at 2000 psi.

*As a motor*—the 8 models have torque capacities from 19 to 230 inch-pounds per 100 psi and are capable of operating continuously at 2000 psi.

*As a pump or a motor* — the unit provides positive, constant displacement—even at low speeds. Vanes are hydraulically balanced for smoother action, longer life, less wear.

Cantilever support for the shaft and bearing assures rigid support for external shaft loads, and minimizes the effect of misalignment. Pressure-equalization reduces surge and pulsation of oil delivery to a minimum.

Simplicity is the key to the versatility, compactness and efficiency of this new pump/motor, making it a worthy addition to the long line of "firsts" by Denison.



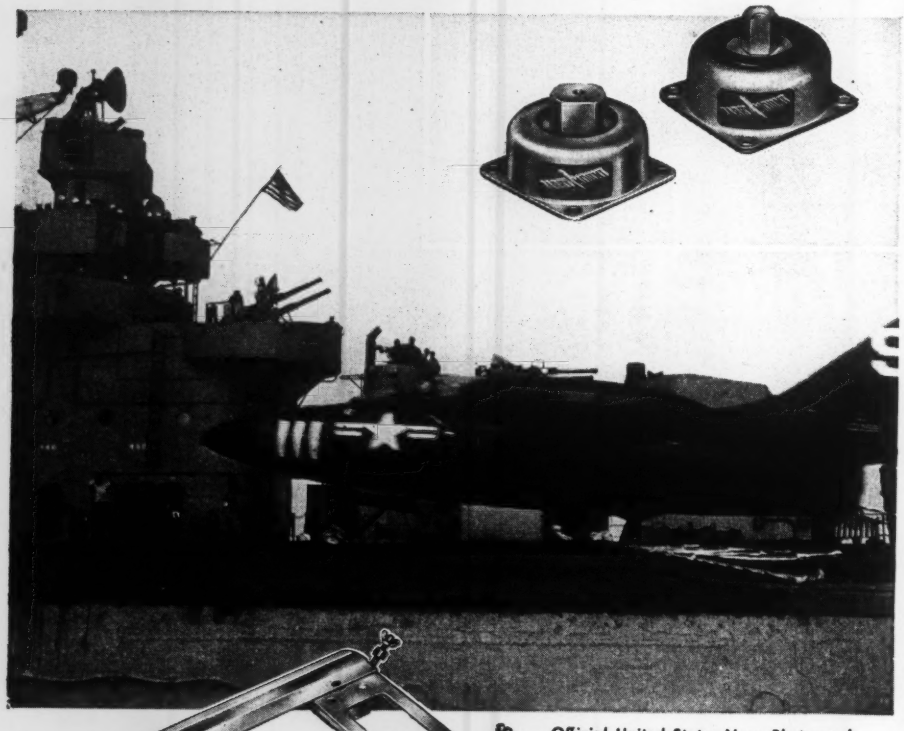

**Write for Bulletin P-5 today!** *It gives full details on this unique, dual purpose HydrOILic Pump/Motor.*

**The DENISON Engineering Co., 1156 Dublin Rd., Columbus 16, Ohio**

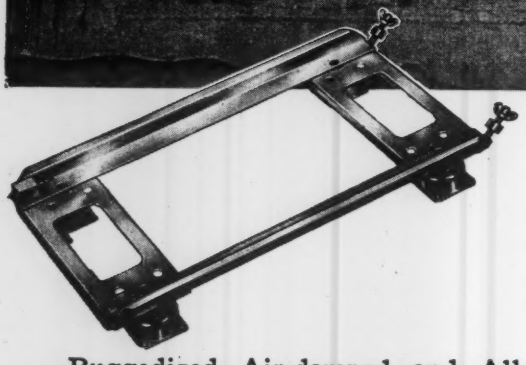
# SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION

## *can YOUR equipment stand the shock of carrier landings? Barrymounts can!*



*Official United States Navy Photograph*



New military specifications for all services require ruggedization of your equipments with their mountings.

Ruggedized Air-damped and All-Metl Barrymounts and mounting bases are now available to meet the shock test requirements of specifications MIL-T-5422 (Aer), MIL-E-5272 (USAF), and AN-E-19. These mountings hold your equipment securely and maintain uniform performance characteristics even after the repeated shock of many aircraft carrier landings.

For full information about Barrymounts and bases, write today for your free copy of each of these Barry catalogs:

**Catalog #524**—Ruggedized Barrymounts and ruggedized mounting bases.

**Catalog #523**—Air-damped Barrymounts and mounting bases.

**Catalog #509**—All-Metl Barrymounts and mounting bases.

THE **BARRY** CORP.

722 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

Atlanta Chicago Cleveland Dallas Dayton Detroit Los Angeles Minneapolis New York Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington


(*Continued from Page* 239)

stallation of two extrusion presses rated at capacities of 8000 and 12,000 tons. The new building, with 400,000 sq ft of floor space, will increase total plant area by about 25 per cent. Plant output will be increased by approximately two million pounds of parts per month.

♦

**Trailmobile Inc.**, Cincinnati, has announced that production facilities of its Canadian subsidiary, **Trailmobile Canada Ltd.**, have been trebeled by the construction of a new manufacturing plant in Scarborough, Ont.

♦

An expansion program which will provide new facilities for the capacitor and the metals and ceramics divisions was announced recently by **P. R. Mallory & Co. Inc.**, Indianapolis. An additional 35,000 sq ft of manufacturing space will be added to the capacitor division for the manufacture of electrolytic capacitors, and the metals and ceramics division will be provided with an additional 27,000 sq ft of space.

♦

**Westinghouse Electric Corp.**, Pittsburgh, has annouced that limited production has begun at its small motor division plant at Union City, Ind.

♦

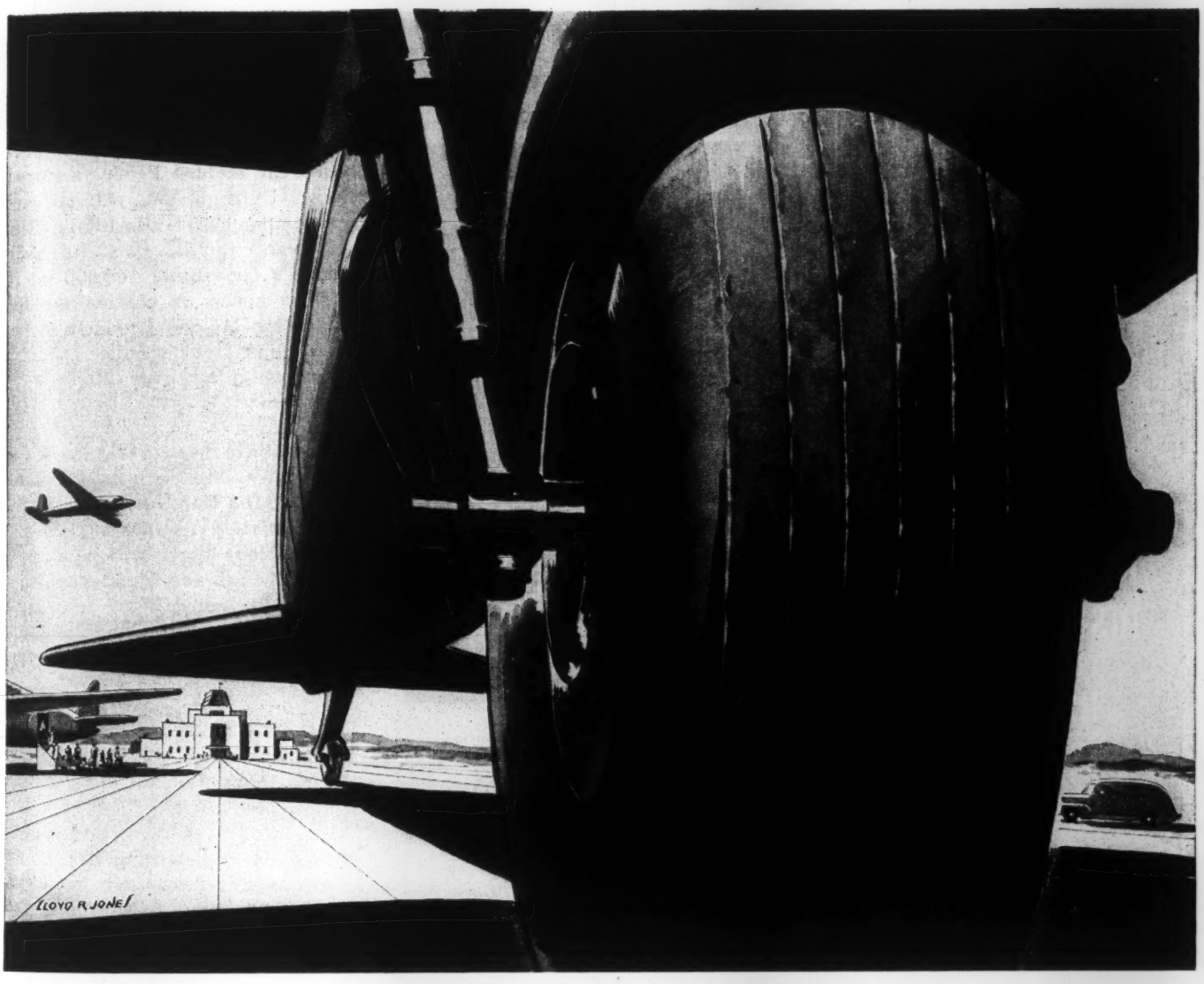
As a result of growing product diversification, Midland Glue Products Co. has changed its name to **Midland Adhesives & Chemical Corp.** The firm is now in full production at its new plant located in Ferndale, Mich.

♦ ♦

**Mueller Brass Co.**, Port Huron, Mich., has announced its acquisition of Valley Metal Products Co., Plainwell, Mich. The new subsidiary will be operated as a division of the parent company, although retaining its own tradename of Vampco.

♦

A one-story structure containing approximately 82,000 sq ft of manufacturing space has been purchased by **John J. Nesbitt Co.**, Philadelphia manufacturer of heating, ventilating and air-conditioning equipment. The newly acquired plant




# Legs for lethal eagles

Legs for lethal eagles—hydraulic landing gear that cushion Uncle Sam's big bombers as they come down to roost—this is just one of the many uses of OSTUCO Tubing by manufacturers in the progressive aircraft industry. Aircraft designers are specifying OSTUCO Tubing for fuel lines, engine mounts, landing gear, and many other applications because of its inherent strength without weight characteristics and the ease with which it can be machined, formed and fabricated to the most exacting requirements.

But whether your products are aeronautical or of a distinctly different nature, you owe it to your future to investigate the advantages of OSTUCO Tubing for improving quality and reducing cost.

We cannot always promise early delivery estimates on new civilian orders, because of military demands, but it will pay you to consult our experienced engineers about OSTUCO Tubing when redesigning your products to meet future competition.

**THE OHIO SEAMLESS TUBE COMPANY**
**Manufacturers and Fabricators of Seamless and Electric Welded Steel Tubing**
***Plant and General Offices: SHELBY, OHIO***

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saves engineering, fabricating and installation costs

using PLATECOILS
(REPLACE PIPE COILS)

in DAIRY CASE WASHERS
DAIRY CAN WASHERS
BONDERIZING SYSTEMS
METAL PARTS WASHERS

Platecoils are not only more efficient but they save time for many departments when used instead of pipe coils in original equipment. For instance, Peters-Dalton, Inc., Detroit, Michigan, has found that use of Platecoils has simplified engineering and estimating. Considerable time is saved in the planning stage by referring to the standard charts of sizes and capacities.

They have found, too, it is less costly to buy Platecoils than to fabricate pipe coils in their own plant. The Platecoils can be installed in a fraction of the time as they do not require the complicated racks and brackets needed for pipe coils.

In addition, because the Platecoils are more efficient, smaller size Platecoils can be used to heat a given tank. This means that extra tank capacity is provided without increasing tank size.

Why pay the high cost of pipe coils when you can heat or cool more efficiently at lower cost, using Platecoils. Ask Platecoil engineers to help you with your next heat transfer problem. There is no obligation. Send too for your copy of bulletin No. P71.

will be used to expand the company's present manufacturing facilities.

♦

**Admiral Corp.,** Chicago, has purchased the **Molded Products Corp.,** also of Chicago, and will operate this company as a subsidiary. The new plant facility includes four buildings containing 100,000 sq ft of floor space. A custom molder of plastics, Molded Products Corp. is equipped to produce plastic pieces weighing over 80 lb.

♦

Plans have been announced for expansion of the Marietta, O., plant of **Remington Rand Inc.,** New York. Approximately 100,000 sq ft of additional floor space will be added. The proposed additional facilities are to be constructed on land owned by the Pennsylvania Railroad, near the present Remington Rand plant.

♦

The T. W. & C. B. Sheridan Co. of New York and the Gray Engineering Co. of Redondo Beach, Calif., have merged to form a new West Coast engineering firm to be known as **Sheridan-Gray Inc.** Offices of the new firm will be at 131 North Benita Ave., Redondo Beach, Calif. The new association brings together two firms engaged in the designing, engineering and manufacturing of special machine tools for the aircraft industry.

♦

**Porter-Cable Machine Co.,** Syracuse, N. Y., has sold its floor sanding machine line to **Clarke Sanding Machine Co.,** Muskegon, Mich. This transaction will enable Porter-Cable to devote more time to the engineering and distribution of portable electric tools.

♦

A new plant has been erected at 5303 Twelfth St., Detroit, Mich., for **Anderson Brass Co.,** producer of valves and fittings.

♦

**General Electric Co.,** Schenectady, N. Y., is undertaking, for the U. S. Air Force, a program to produce armament equipment which the company has developed for the Boeing B-47 Stratojet bomber. The Electronics division at Syracuse,

# FOR DEPENDABLE LOW SPEED MACHINERY MFR. SELECTS

## STERLING SLO-SPEED!

*Sterling Slo-Speed geared motors meet exacting requirements for the drum reconditioning equipment we manufacture by giving us the one best low speed for maximum production and highest quality . . . rugged construction gives dependable low cost operation . . . gear design and construction provide economical application to various load conditions, states Mr. W. C. Babin of Babin Machine Works, Beaumont, Texas.*

### STERLING SLO-SPEED GIVES YOU THE ONE BEST LOW SPEED AND

gives uninterrupted service—carries heavy overhung loads—provides versatile mounting and flexibility in arrangement of machinery—saves valuable space—provides greater safety—costs less to install and use. An indispensable source of low speed power for:

| | | |
|---|---|---|
| **Agitators** | **Dryers** | **Presses** |
| **Blenders** | **Feeders** | **Pumps** |
| **Blowers** | **Kilns** | **Screens** |
| **Conveyors** | **Mills** | **Tumblers** |
| **Cookers** | **Mixers** | **Etc., etc.** |

*OTHER STERLING ELECTRIC POWER DRIVES:*
- **STERLING SPEED-TROL (VARIABLE SPEED) MOTORS**
- **STERLING KLOSD AND KLOSD-TITE (NORMAL SPEED) MOTORS**

*DRIP-PROOF • SPLASH-PROOF • TOTALLY ENCLOSED*

70 ILLUSTRATIONS showing how Sterling Electric Power Drives reduce production costs. Write for Bulletin No. D-102

### OUTSTANDING FEATURES:

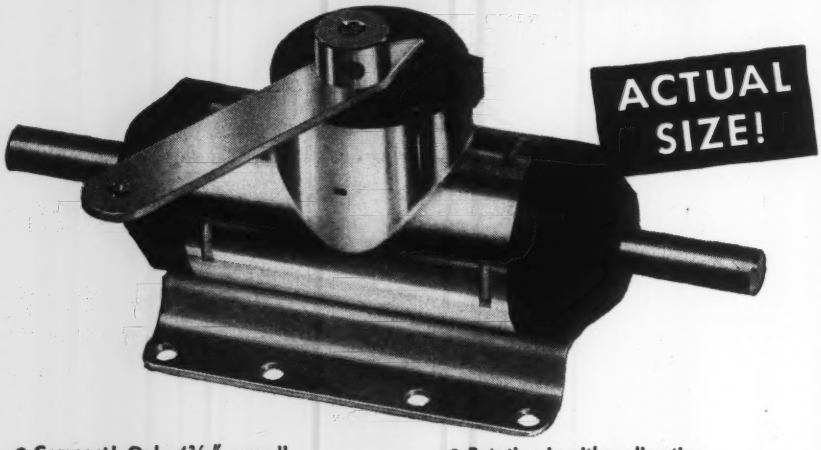
Simplified gear system—balanced design—compact—rugged—highly efficient—abundant lubrication—low output shaft—positive oil seals—Herringbone Rotor—protected—streamlined—direct through ventilation—quiet operation—AGMA speeds—extremely long life—every unit will operate in any position.

# STERLING ELECTRIC MOTORS

Plants: New York City 51; Van Wert, Ohio; Los Angeles 22; Hamilton, Canada; Santiago, Chile.

Offices and distributors in all principal cities.

VARIABLE SPEED DRIVES




- Compact! Only 4 3/16" overall
- Light! Weigh only 5½ oz.
- Continuously variable speeds over a wide range
- Knob, lever, push-rod or gear control (Lever control illustrated)
- Rotation in either direction
- Coaxial shafts for in-line construction
- Ball-bearings throughout
- Completely sealed
- Permanently lubricated for trouble-free high/low temperature service
- Operate in any position

*Write for Bulletin 99*

FIXED RATIO SPEED CHANGERS (Gear Type)

- Only 1.050" diameter!
- Single section weighs only 3 oz.
- STANDARD ratios from 10:9 to 531,441:1!
- Hobbed gears for smooth, precision running
- Anti-backlash units . . . virtually zero backlash in either direction
- Completely sealed
- Permanently lubricated
- Mount in any position

*Write for Bulletin 100*

**MINIATURE COMBINATION FIXED AND VARIABLE SPEED CHANGERS**

For applications requiring variable speed at a reduced nominal output speed, combinations of Metron Variable Speed Drives and Fixed Ratio Speed Changers are available in compact, integral units. Ask for Technical Data, or write giving your requirements for prompt engineering recommendations and prices.

**METRON INSTRUMENT COMPANY**

442 Lincoln Street • Denver 9, Colorado

Metron


N. Y., and the Aeronautic and Ordnance Systems division at Schenectady will be utilized to meet production requirements for the equipment. Also, the Air Force has designated the Crosley division of **Avco Mfg. Corp.** at Cincinnati as an additional source of supply.

♦

Executive, sales and engineering offices of **The Smith & Mills Co.**, shaper manufacturer, have been established in the Chicago Daily News Bldg., 400 West Madison St., Chicago 6, Ill. Business of the firm has been acquired from **Hamilton-Thomas Corp.**, by interests represented by A. G. Bryant, who has become president of Smith & Mills.

♦

Expanded activity in the development, design and production of electronic computers, control systems and special devices has led **The Austin Co.**, New York, to establish new headquarters for its Special Devices division in the Port of New York Authority Bldg. at 76 Ninth Ave., New York 11, N. Y. Straight-line manufacturing and assembly methods have been introduced as a result of orders calling for production runs of identical units.

♦

The new **Ohio Axle & Gear** division of **Timken-Detroit Axle Co.**, Detroit, has begun production of axles and transfer cases for military trucks. The new plant, located at Newark, O., occupies approximately 400,000 sq ft of floor space and is a completely integrated manufacturing unit for machining, heat treating and assembly operations.

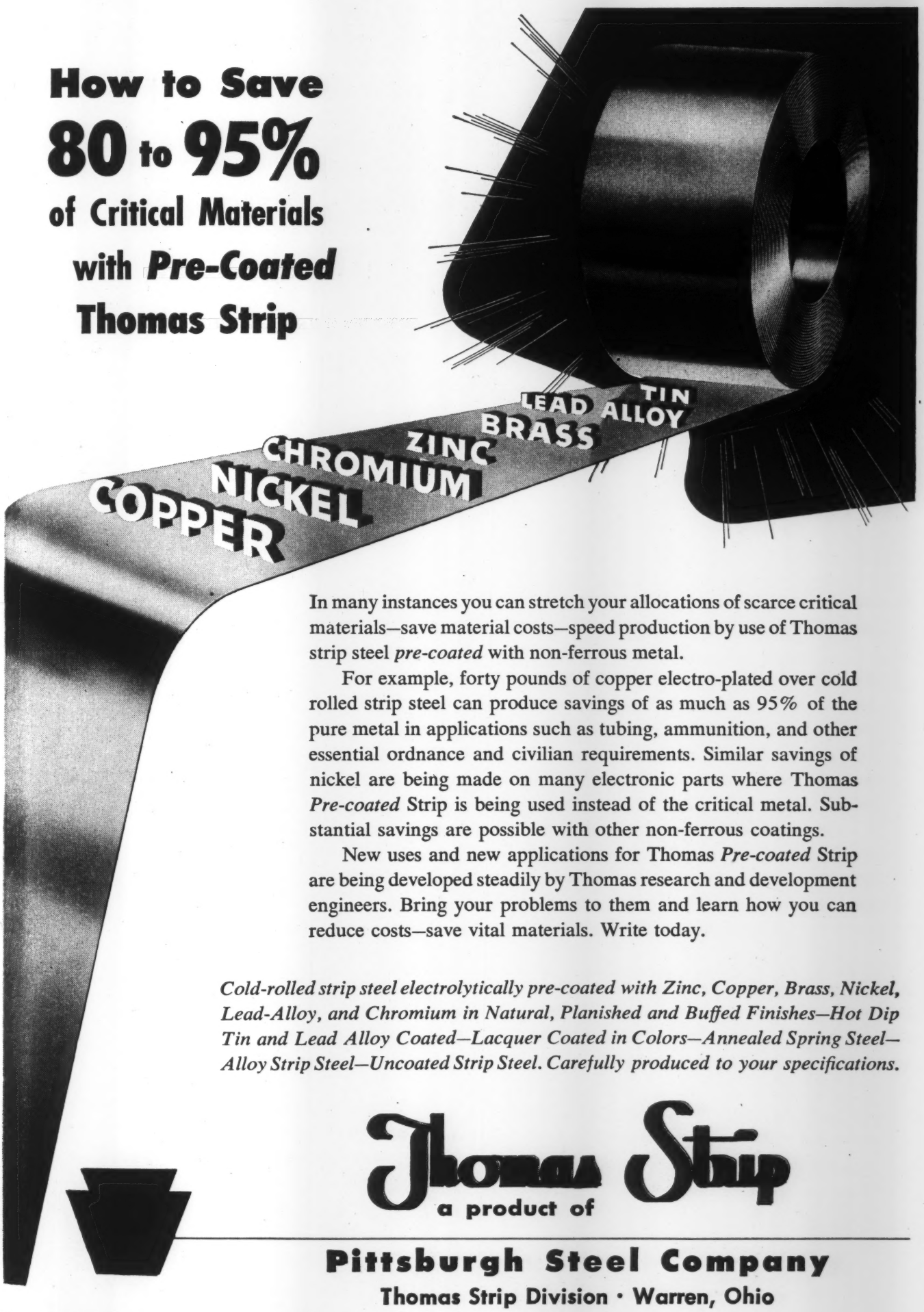
♦

Announcement has been made of the formation of the **Flexoid Conveyor Co.** as a division of the **Smith Power Transmission Co.**, Cleveland. The division will develop, design, construct and install conveyor equipment for diversified industries.

♦

**Cyril Bath Machinery Co.**, Cleveland, has announced plans for the construction of a branch plant comprising 50,000 sq ft of additional area. The new plant will be located at Solon, O., and will specialize in defense production of the company's new rotary draw former.

# How to Save 80 to 95% of Critical Materials with *Pre-Coated* Thomas Strip




In many instances you can stretch your allocations of scarce critical materials—save material costs—speed production by use of Thomas strip steel *pre-coated* with non-ferrous metal.

For example, forty pounds of copper electro-plated over cold rolled strip steel can produce savings of as much as 95% of the pure metal in applications such as tubing, ammunition, and other essential ordnance and civilian requirements. Similar savings of nickel are being made on many electronic parts where Thomas *Pre-coated* Strip is being used instead of the critical metal. Substantial savings are possible with other non-ferrous coatings.

New uses and new applications for Thomas *Pre-coated* Strip are being developed steadily by Thomas research and development engineers. Bring your problems to them and learn how you can reduce costs—save vital materials. Write today.

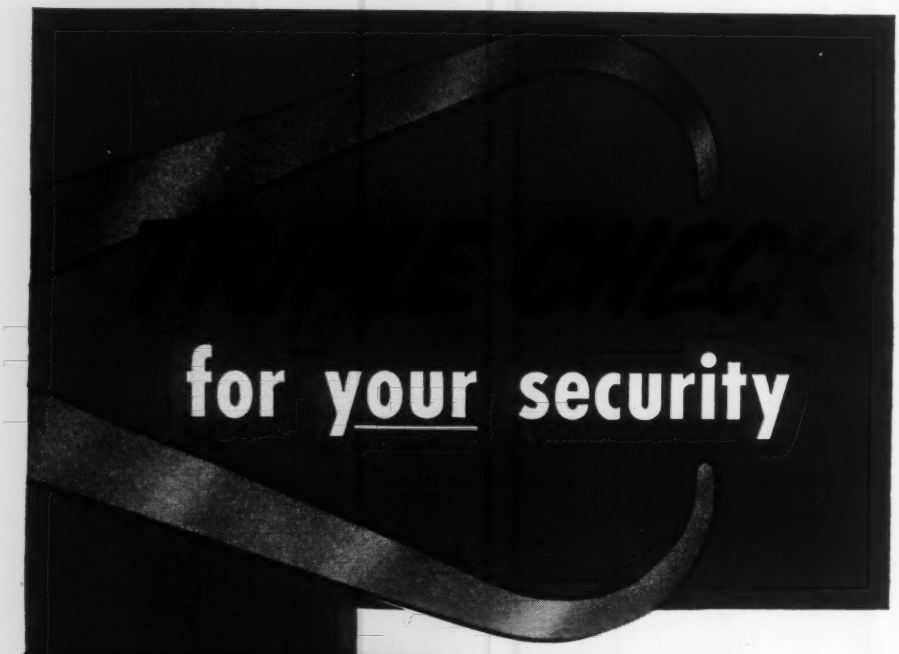
*Cold-rolled strip steel electrolytically pre-coated with Zinc, Copper, Brass, Nickel, Lead-Alloy, and Chromium in Natural, Planished and Buffed Finishes—Hot Dip Tin and Lead Alloy Coated—Lacquer Coated in Colors—Annealed Spring Steel—Alloy Strip Steel—Uncoated Strip Steel. Carefully produced to your specifications.*

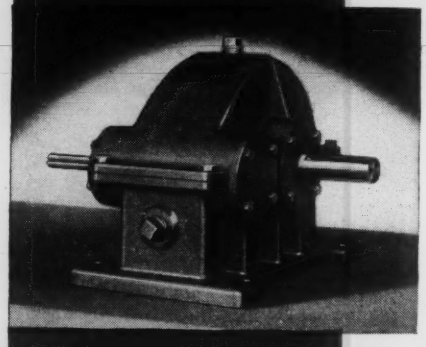
Thomas Strip

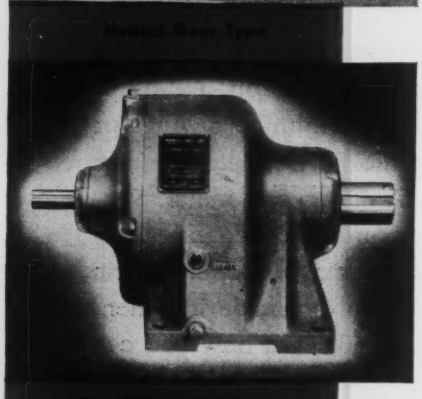
a product of

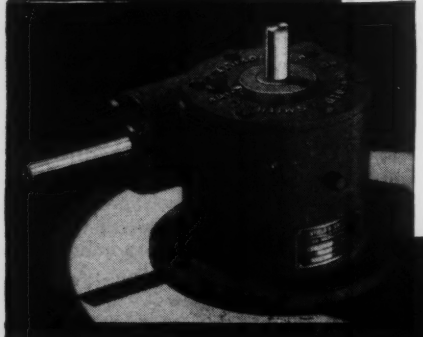
**Pittsburgh Steel Company**

**Thomas Strip Division · Warren, Ohio**







There are numerous reasons why machinery and equipment makers are standardizing on Winsmith Speed Reducers on such a large scale. The fact that Winsmith is the most complete, standardized line available from stock (1/100 to 85 hp) is hardly sufficient in itself.

*Tested Winsmith performance* . . . assuring quiet, smooth operation; long operating life; minimum maintenance . . . that's what *really* counts with design engineers.

And that performance-testing is three-fold . . . it's the *Triple Check* that *every* Winsmith reducer undergoes: (1) All components are first rigidly checked for accuracy and finish before assembly. (2) During set stages in assembly, complete conformity to specifications, precise adjustment of bearings, accurate centering of gears and perfect tooth contact are all closely checked. (3) Each completed unit is run-in under load and carefully checked for rated performance.

*Information in "Save Through Standardization" folder. Write.*

WINSMITH
SPEED REDUCERS

AGMA

Winsmith, Inc.


# Association
## ACTIVITIES

CHICAGO's Museum of Science and Industry is to be the site of the **Centennial of Engineering,** which will be held this year. This celebration, observing the 100th anniversary of the founding of the first national society of civilian engineers in the United States—the American Society of Civil Engineers—honors engineers in every branch of the profession. The purpose of the event is to tell the story of engineering to the public in terms and dramatic interpretations that can be easily understood.

The exhibit prepared for the centennial will be ready this year and will continue for five years. A stage production will be presented daily this summer and a convocation of more than 40 national and international engineering societies and associations will be held from September 3 to 13.

Funds for the centennial are being provided by engineering, industrial, and business organizations. Leading figures in technical progress as well as 48 national and international engineering societies will participate.

♦

At its recent Honors Night Dinner in New York the **Institute of the Aeronautical Sciences** presented the following awards.

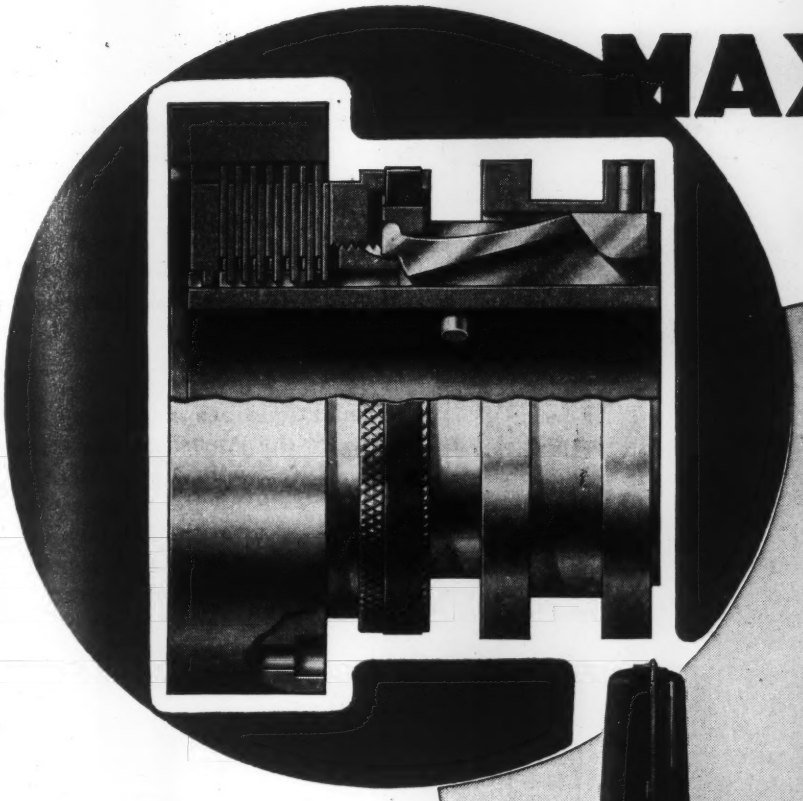
*Robert M. Losey Award* to Ivan Ray Tannehill, U. S. Weather Bureau, "in recognition of outstanding contributions to the science of meteorology. . . ."

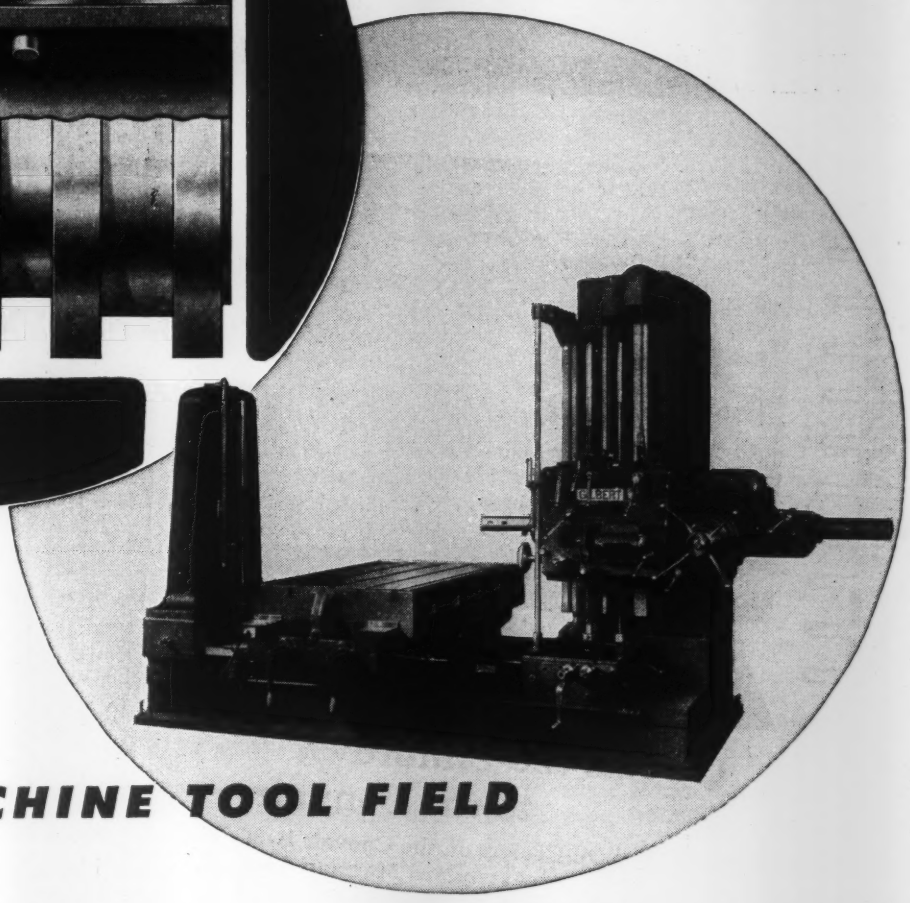
*John Jeffries Award* to Captain John R. Poppen (MC), USN (Ret.) "for outstanding contributions to the advancement of aeronautics through medical research."

*Sylvanus Albert Reed Award* to Edward H. Heinemann, Douglas Aircraft Co. Inc., "for design and development of experimental aircraft. . . ."

*Lawrence Sperry Award* to Robert C. Seamans, Jr., Massachusetts Institute of Technology, "for a system of determining dynamical

# MAXITORQ
## KEEPS GOOD COMPANY





## ...IN THE MACHINE TOOL FIELD

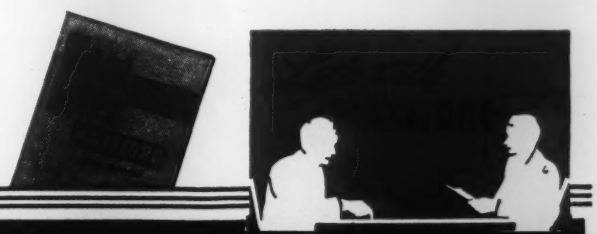
It is a pleasure to express our appreciation to the Cincinnati Gilbert Machine Tool Co. for their selection of our No. 25 Maxitorq Clutch as original equipment in their Gilbert Horizontal Boring, Drilling and Milling machines.

The multiple "floating disc" single Maxitorq Clutch (3 h.p. at 100 r.p.m.) is located on the initial shaft in the Unit Head, controlling the r.p.m. of the spindle.

Maxitorq Clutches are available in 8 standard sizes, fractional to 15 h.p.... single or double, wet or dry. "Floating discs" ride free in neutral, preventing drag, abrasion, heating. Clutch is completely assembled on the body, shipped ready to slip onto a shaft. All assembly, adjustments and take-down are manual. Varied Maxitorq Driving Cups may be ordered for specific needs.

Within its capacity there's no more compact or dependable clutch than Maxitorq. Check with our Engineers for solution of your problems in power transmission.

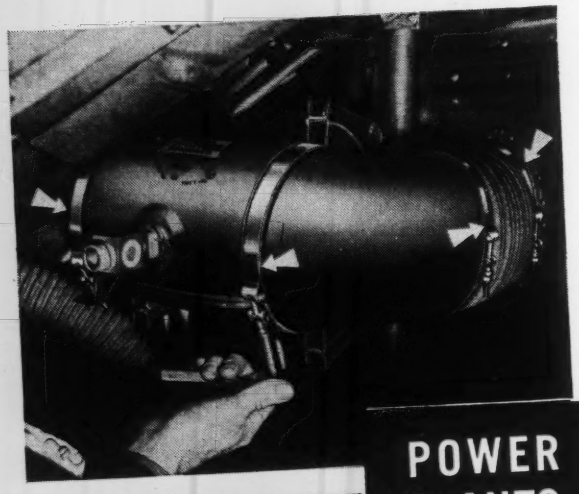
*Send for Bulletin MD3, "Maxitorq Goes to Work"... showing 16 interesting installations by leading industrial users.*



**THE CARLYLE JOHNSON MACHINE COMPANY**
MANCHESTER • CONNECTICUT

4CJ51

T-BOLTS
ENGINEERS NOTEBOOK
T-BOLTS
T-BOLTS



POWER PLANTS

MARMAN

Clamps the Clifford to the Convair

The Clifford Oil Coolers on the Convair B-36-D are held in place by standard Marman Clamps and Straps. Bellows ducting at the inlet is held securely in place under varying conditions of vibration and stress by Marman Clamps with hi-safety T-Bolt latches. The unit is attached to the structure with two Marman Straps utilizing the same secure latch design.

These clamps and straps are part of a specialized family of fastening and connecting devices pioneered and perfected by Marman and found today in every modern aircraft.

Save Time, Weight, Money with Marman

FOR INFORMATION AND LATEST CATALOG ON V-BANDS, WRITE DEPT. M-3

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T-BOLTS
T-BOLTS

STANDARD CLAMPS FOR SPECIAL APPLICATIONS

characteristics of an airplane and matching them to automatic controls. . . ."

*American Honorary Fellow* conferred on Leroy Randle Grumman, Grumman Aircraft Engineering Corp.

*Foreign Honorary Fellow* conferred on John Hamilton Parkin, National Aeronautical Establishment, Canada.

♦

Nominations are now being received by the **American Die Casting Institute** for its *Annual Doehler Award.* This award is presented each September at the annual meeting of the Institute and consists of a plaque and a cash honorarium of at least $500. Recipients of the award are selected "for outstanding contributions to the advancement of the die casting industry and process." Nominations will be received annually from January 1 to April 30 by: Award Committee, American Die Casting Institute, 366 Madison Ave., New York 17, N. Y.

♦

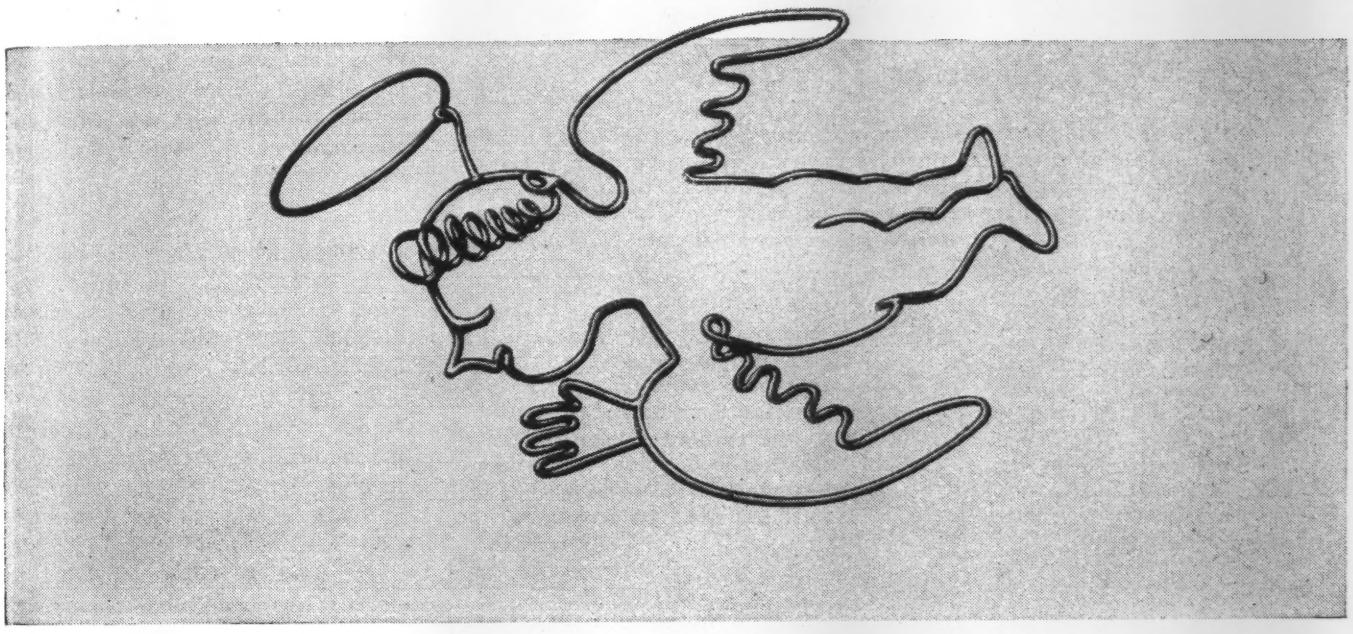
Newly elected at the **Society of Plastics Engineers'** Eighth National Technical Conference were the following officers for 1952: president, William O. Bracken, Hercules Powder Company; vice president, Walter Oelman, Standard Molding Corporation; treasurer, Don F. Hoffman, Evans-Winter-Hebb Inc.; and secretary, John LaBelle, Koppers Co.

First, second, and third prize awards in the Society's *Annual Prize Paper Contest* were made to D. J. Sloane, Lester Engineering Corp.; William Kosobud, Detroit Mold Engineering; and Austin Herbst, Irvington Varnish and Insulator Co.

♦

A. P. Cochran, Cochran Foil Co. Inc., was re-elected president of **The Aluminum Association** for the ensuing year at their annual meeting in New York. Also re-elected were Arthur V. Davis, Aluminum Company of America, as chairman of the board; and I. T. Bennett, Revere Copper and Brass Inc.; L. M. Brile, Fairmount Aluminum Co.; and E. G. Fahlman, The Permold Co., as vice presidents.

# THE WIRE WITH THE **Perfect Temper**



Many a production man thinks Chase engineers are "angels" for producing wire that unwinds from the coil smoothly and without twist. It's uniform in gauge, temper and color; has superior heading or flowing characteristics.

There's a Chase wire for most applications. Write for *FREE* booklet—"Chase Cold Heading Extruded Brass and Copper Alloy Wire" giving physical and fabrication properties, applications, weights per 1000 feet and feet per lb.

**CMP orders.** We can make favorable mill deliveries on authorized Controlled Materials orders. In many cases our warehouses can ship from stock. Your inquiries are invited.

● **CHASE TECHNICAL SERVICE**
*Our metallurgical engineers are familiar with military specifications for brass and copper for ordnance components, and will be glad to consult with you on the selection of these metals for defense orders.*

**Chase BRASS & COPPER**

**WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION**

• *The Nation's Headquarters for Brass & Copper*

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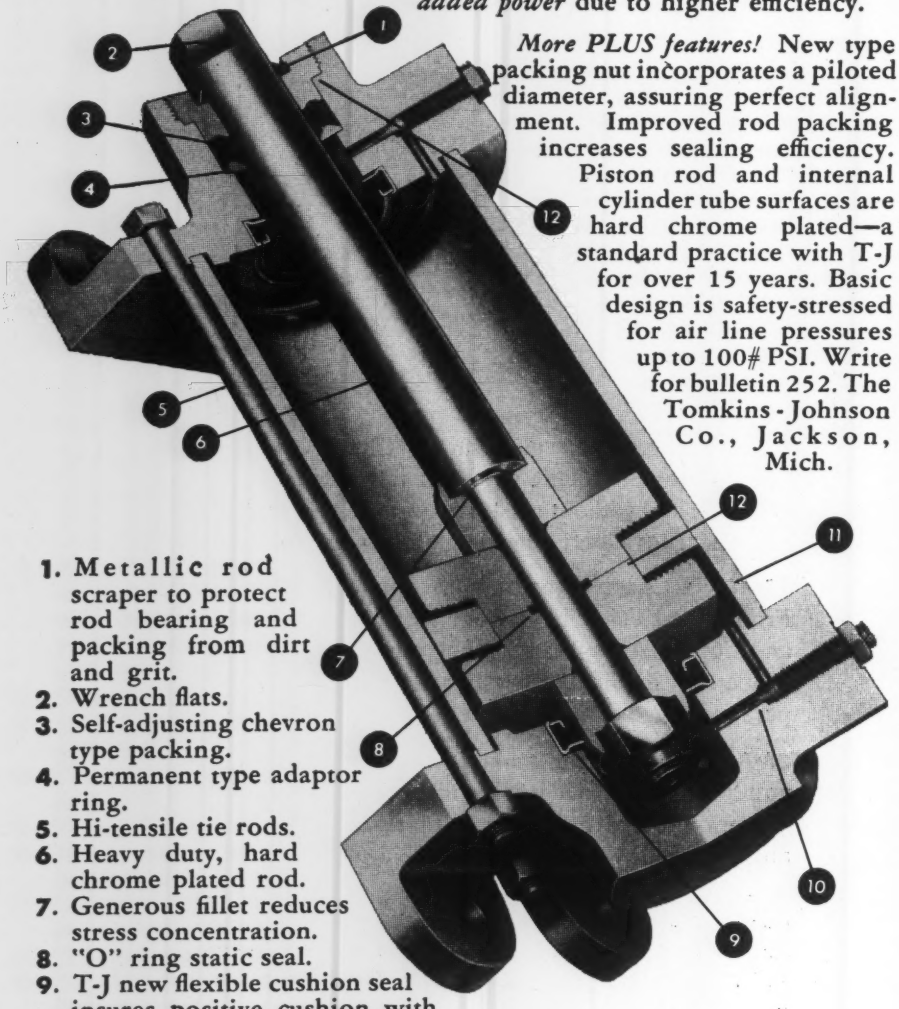
# New Flexible Sealing...

## T-J AIR CYLINDER

**Designed with revolutionary application of**

## Super-Cushion

It's *sealed with pressure*—a revolutionary T-J application of flexible sealing that insures positive cushion action combined with automatic valving action for fast return stroke . . . eliminates binding and sticking . . . operates with *low friction, minimum wear,* and *added power* due to higher efficiency.




*More PLUS features!* New type packing nut incorporates a piloted diameter, assuring perfect alignment. Improved rod packing increases sealing efficiency. Piston rod and internal cylinder tube surfaces are hard chrome plated—a standard practice with T-J for over 15 years. Basic design is safety-stressed for air line pressures up to 100# PSI. Write for bulletin 252. The Tomkins-Johnson Co., Jackson, Mich.

1. Metallic rod scraper to protect rod bearing and packing from dirt and grit.
2. Wrench flats.
3. Self-adjusting chevron type packing.
4. Permanent type adaptor ring.
5. Hi-tensile tie rods.
6. Heavy duty, hard chrome plated rod.
7. Generous fillet reduces stress concentration.
8. "O" ring static seal.
9. T-J new flexible cushion seal insures positive cushion with automatic valve action for fast return stroke. (Patent applied for)
10. Fine cushion adjustment.
11. Heavy wall precision honed hard chrome plate.
12. Controlled packing compression with metal to metal contact.

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**ASTE Industrial Exposition**
**Chicago . . . March 17-21**

**36 YEARS' EXPERIENCE** T-J

**TOMKINS-JOHNSON**

RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS


SALES AND SERVICE

# Personnel

ANNOUNCED recently was the election of **J. A. Sizer** as president of Industrial Gear Mfg. Co., Chicago. Mr. Sizer was formerly vice president in charge of sales. He succeeds **A. M. Scharek,** founder of the firm, who was elected as chairman of the board and chief executive officer.

♦

**William M. Wallace** has been appointed an assistant to the vice president of the general machinery division of Allis-Chalmers Mfg. Co., Milwaukee. Since 1947 he has been special assistant to **G. V. Moody,** manager of the processing machinery department. Mr. Wallace joined the company in 1937 and served as a sales representative in the Denver and Pittsburgh district offices before entering the processing machinery department.

♦

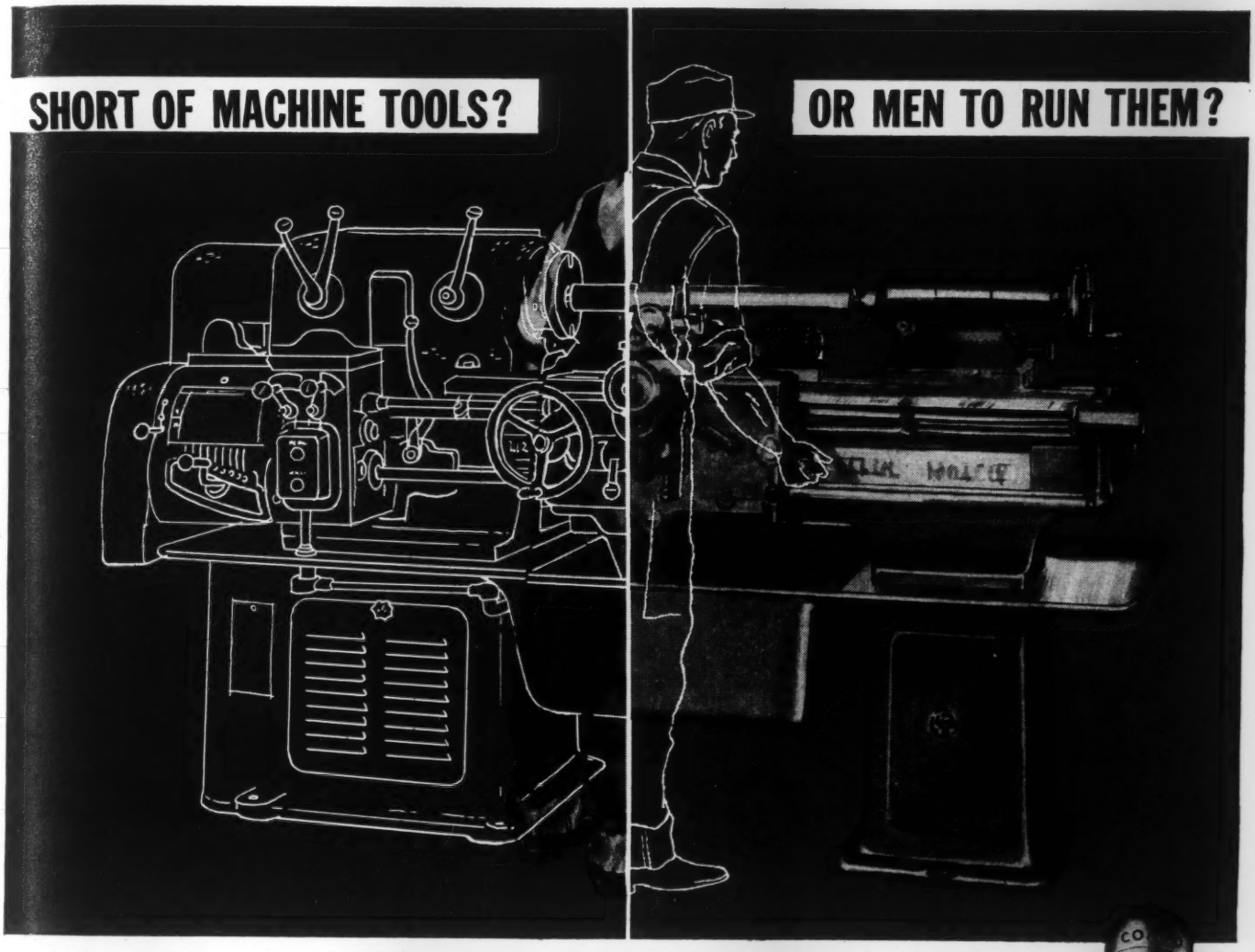
Bryant Machinery & Engineering Co., Chicago, has appointed **Guy Hubbard** as assistant general sales manager. Mr. Hubbard joined Windsor Machine Co., Windsor, Vt., in 1915. He continued with its successor, National Acme Co., at Windsor and at Cleveland on machine tool design, sales promotion and eventually as advertising manager. He left National Acme to join the Penton Publishing Co. as a technical editor and has served as machine tool editor of *Steel* for the last 13 years.

♦

**J. Dudley Lockrem,** vice president, has been named sales manager of Scully-Jones and Co., Chicago.

♦

The appointment of **George E. Goodrich** to the position of assistant manager of the industrial department of Westinghouse Electric Corporation's Apparatus Division has been announced. He was formerly resale manager of the company's Middle Atlantic district with headquarters in Philadelphia. Mr. Goodrich joined




## Investigate *die-formed*

# "COMPO"® and "POWDIRON"® parts!

Parts die-formed by *powder metallurgy* methods from "COMPO" porous bronze and "POWDIRON" sintered iron are *ready for installation* when they reach you. They're accurately die-formed at Bound Brook to the final dimensions you want. There's no need for machining operations at your plant!

When you specify "COMPO" and "POWDIRON" parts in your product designs, you free critical tools and skilled manpower for other tasks. And you can speed up production, because "COMPO" and "POWDIRON" are in freer supply than some other materials.

*Write on company letterhead for information on "COMPO" and "POWDIRON".*

*Better Buy Bound Brook*

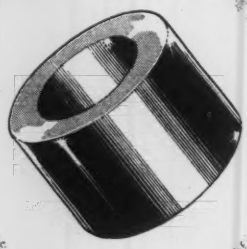
"COMPO" • "POWDIRON" • "BOUND BROOK"

**BOUND BROOK**

**BOUND BROOK, N. J. • BOUND BROOK 9-0441**

**Manufacturers of bearings and parts — Established 1883**

WORKS WHERE OTHERS WON'T



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**GRAPHALLOY OILLESS BEARINGS**

SPECIFY GRAPHALLOY WITH CONFIDENCE

TRADE MARK REG. U. S. PAT. OFF.

SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — *OR SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS* ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* ● EXCELLENT AS A CURRENT-CARRYING BEARING.

GRAPHITE METALLIZING CORPORATION

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Westinghouse in 1934. After completing the graduate student course he was assigned to the general sales department at East Pittsburgh; he transferred to the Philadelphia sales office in 1936. He served as an application engineer from 1940 to 1943 and four years later assumed the duties of Middle Atlantic district resale manager.

♦

Federated Metals Division, American Smelting and Refining Co., has added three representatives to its sales force. **Alfred L. Lee** will cover the Philadelphia, southern New Jersey and eastern Pennsylvania areas; **Edward R. Bergin** will be the representative in the metropolitan New York area; and **Alfred Blackstone** will cover the states of North Carolina, South Carolina, the eastern half of Georgia and all but the extreme western part of Florida.

♦

**George J. Zahringer Jr.** has joined The Dow Chemical Co. at its Midland, Mich., offices to assist in the developmental sale of solvents for industrial applications. Mr. Zahringer was formerly associated with the sales department of the American Mineral Spirits Co. in Chicago.

♦

Formerly district manager of the Chicago district, **Jack E. Cole** has been appointed sales manager of the equipment sales division of Raybestos - Manhattan Inc. Succeeding Mr. Cole is **F. M. Moyes,** who has been assistant district manager in Chicago.

♦

**Fred P. Biggs** has been elected a vice president of American Brake Shoe Co., New York. Mr. Biggs, who is also president of the Brake Shoe and Castings division, has served in several sales positions since he joined the company in 1916.

♦

United States Rubber Co. has announced the appointment of **Louis J. Coppola** as manager of government sales for the mechanical goods division. He succeeds **George H. Pendleton,** who is retiring from the company after 46 years of service. Mr. Coppola joined U. S. Rubber in 1925 in the

**Parker**

INDUSTRIAL TUBE FITTING STOCKS CARRIED BY

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| AKRON, O. | B. W. Rogers Co. 850 So. High St. (9) |
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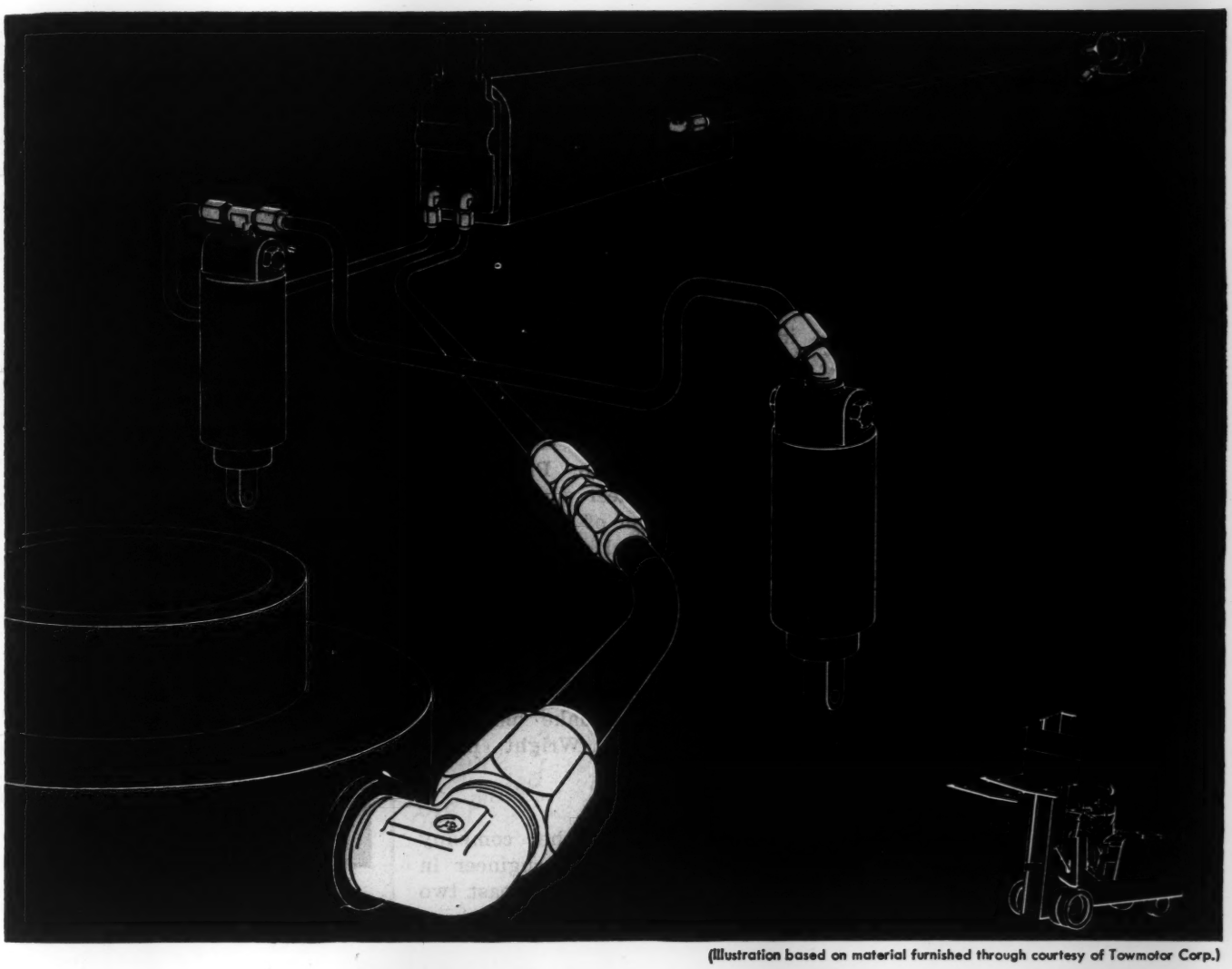
| BEAUMONT, Tex. | Standard Brass & Mfg. Co. 705 Milam St. |
| BOSTON, Mass. | A. E. Borden Co., Inc. 176 Brookline Ave. (15) |
| BUFFALO, N. Y. | Whitehead Metal Products Co. 2128 Elmwood Ave. (7) |
| CAMBRIDGE, Mass. | Whitehead Metal Products Co. 281 Albany St. (39) |
| CEDAR RAPIDS, Ia. | Globe Machinery & Supply Co. 309 8th Ave., S.E. |
| CHICAGO, Ill. | Wallace Tube Co. 1300 Diversey Parkway (14) |
| CINCINNATI, O. | Williams & Co. 3231 Fredonia Ave. (29) |
| CLEVELAND, O. | W. M. Pattison Supply Co. 777 Rockwell Ave. (14) B. W. Rogers Co. 1900 Euclid Ave. (15) Williams & Co. 3700 Perkins Ave. (14) |
| COLUMBUS, O. | Williams & Co. 851 Williams Ave. (8) |
| DALLAS, Tex. | Metal Goods Corp. 6211 Cedar Springs Rd. (9) |
| DAVENPORT, Ia. | Globe Machinery & Supply Co. 410 East Second St. |
| DAYTON, O. | J. N. Fauver Co. 1534 Keystone Ave. (10) |
| DENVER, Colo. | Metal Goods Corp. 2425 Walnut St. |
| DES MOINES, Ia. | Globe Machinery & Supply Co. East First & Court Ave. (6) |
| DETROIT, Mich. | J. N. Fauver Co. 49 West Hancock St. (1) |
| HARRISON, N. J. | Whitehead Metal Products Co. 1000 South Fourth Ave. |
| HOUSTON, Tex. | Metal Goods Corp. 711 Milby St. (3) Standard Brass & Mfg. Co. 2018 Franklin St. (1) |
| INDIANAPOLIS, Ind. | F. H. Langsenkamp Co. 229 E. South St. |
| KANSAS CITY, Mo. | Metal Goods Corp. 1300 Burlington Ave. (16) |
| KNOXVILLE, Tenn. | Leinart Engineering Co. 412 E. 5th Ave. |
| LOS ANGELES, Cal. | Haskel Engineering & Sup. Co. 721 W. Broadway, Glendale (4) Metropolitan Supply Co. 353 East 2nd St. (12) |
| MEMPHIS, Tenn. | J. E. Dilworth Co. 730 South Third St. |
| MILWAUKEE, Wis. | Morman Belting & Supply Co. 522 W. State St. (3) Wallace Tube Co. 838 So. 6th St. (4) |
| MINNEAPOLIS, Minn. | Vincent Brass & Copper Co. 100 North 2nd St. (1) |
| NEW ORLEANS, La. | Metal Goods Corp. 432 Julia St. (12) |
| NEWPORT NEWS, Va. | Noland Company 27th St. & Virginia Ave. |
| NEW YORK, N. Y. | Whitehead Metal Products Co. 303 West 10th St. (14) |
| NORFOLK, Va. | R. W. Hudgins & Son 3 Commerce St. (10) |
| PHILADELPHIA, Pa. | Louis H. Hein Co. 15 West Lancaster Ave. Ardmore, Pa. Whitehead Metal Products Co. 1955 Hunting Park Ave. (40) |
| PITTSBURGH, Pa. | Williams & Co. 901 Pennsylvania Ave. (33) |
| PORTLAND, Ore. | Hydraulic Power Equipment Co. 2316 N. W. Savier St. (10) |
| ROANOKE, Va. | Noland Company 11 Salem Ave. (10) |
| SAN FRANCISCO, Cal. | General Machinery & Sup. Co. 1346 Folsom St. (3) |
| SEATTLE, Wash. | Eagle Metals Co. 4755 First Avenue South (4) |
| ST. LOUIS, Mo. | Metal Goods Corp. 5239 Brown Ave. (15) |
| SYRACUSE, N. Y. | Whitehead Metal Products Co. 207 West Taylor St. (4) |
| TOLEDO, O. | Williams & Co. 650 E. Woodruff Ave. (2) |
| TULSA, Okla. | Metal Goods Corp. 302 North Boston (3) |
| EXPORT | Mercator Corp. 438 Walnut St. Reading, Pa. |
| CANADA | Railway & Power Engineering Corp. Ltd., Montreal, Toronto |

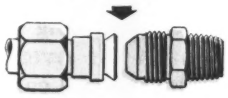


(Illustration based on material furnished through courtesy of Towmotor Corp.)

# Tube it up...Forget it!

## WITH PARKER TRIPLE-LOK FITTINGS

**This does it**



Triple-lok . . . 3-piece flare fitting famous for its sleeve . . . the easiest way to install tubing systems. Made in brass, steel, stainless steel, aluminum alloy.

**Precision Mark of**

**Leakproof Tube Fittings**

Take hydraulic lift trucks, for example, where users cannot stand for failure due to leakage in the line connections. More and more manufacturers of materials handling equipment are using PARKER Triple-lok Fittings to ensure safer, more efficient and longer, trouble-free operation.

PARKER Triple-lok Fittings—as specified by the S.A.E. Hydraulic Tube Fitting Standards and J.I.C. Hydraulic Standards—are designed and precision made to be leakproof under even the severest conditions of vibration—elevated temperatures—high pressures—and repeated assembly . . . and to hold leakproof beyond tube bursting pressures. You will find that PARKER Triple-lok Fittings have been adopted as standard for all kinds of equipment where down time due to leakage is too costly to be tolerated.

So tube it up and forget it . . . with Triple-lok Fittings. Ask your PARKER Distributor, or write us direct for PARKER Tube Fitting Catalog 4300. The PARKER Appliance Company, 17325 Euclid Avenue, Cleveland 12, Ohio.

**Parker**

**TUBE FITTINGS • VALVES • O-RINGS**

Plants in Cleveland • Los Angeles • Eaton, Ohio • Berea, Ky.

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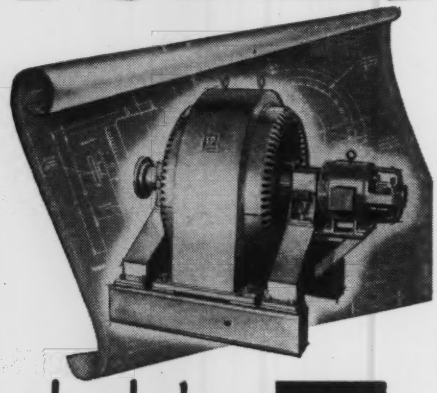
POWER



look to... EP

Since 1909, the job of The Electric Products Company has been to create and develop special electrical rotating equipment . . . motors and generators to do existing jobs better or to reach into new fields to do jobs that couldn't be done before. The natural "by-product" of our more than 40 years of specialization is that you get equipment designed and built to the exact requirements of your application . . . equipment that has greater dependability, longer life and that requires less maintenance.

Send in the coupon below for detailed information about our Custom-Engineered synchronous motors and generators . . . d-c motors and generators . . . induction motors . . . battery chargers . . . frequency changers.

A nation-wide sales engineering and service organization stands ready to meet all User requirements.

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Attach coupon to your letterhead for your copy of Bulletin 2-200.

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STREET_____
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X-74

sales department of the New York branch, and his career has been devoted to selling operations connected with belting, hose, packing, molded specialties and the other products in the mechanical goods line. Prior to his present appointment he was assistant manager of the government sales department.

♦

**J. M. Johns,** general manager of industrial sales for Libbey-Owens-Ford Glass Co., Toledo, O., since 1943, has been appointed general manager of the company's new Fiber-Glass division. He succeeds **Robert E. Worden,** Philadelphia consulting engineer who served as general manager of the division in its developmental stage.

♦

Tube Turns Inc., Louisville, Ky., has announced the appointment of **Lincoln D. Hall** as district manager in charge of the mid-continent territory. He will make his headquarters in the Wright Bldg., Tulsa, Okla.

♦

Affiliated with the company since 1943 and sales engineer in the Chicago area for the past two years, **Byron E. Snow** has been named manager of the new Chicago office of Aeroquip Corp., Jackson, Mich. The new office is located at 1033 South Blvd., Oak Park, Ill.

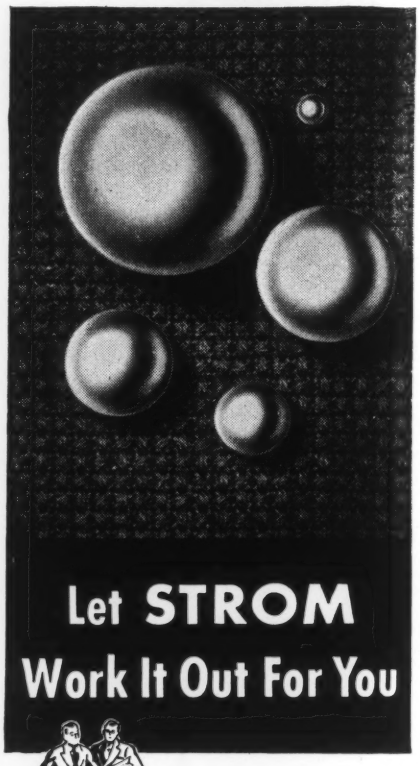
♦

**Arthur K. Atkinson Jr.** has been appointed sales manager of the Industrial Division of Greer Hydraulics Inc., Brooklyn, N. Y.

♦

Appointment of two new district sales managers and three new factory representatives has been announced by New York Belting and Packing Co., Passaic, N. J. **Carl G. Link Jr.,** formerly Chicago representative, was named northern district sales manager covering the states of Iowa, Indiana, Illinois, northwestern Pennsylvania, northern Ohio, southern Wisconsin and northern New York. He will make his headquarters in Chicago. **William I. Butler,** formerly factory representative in Memphis, Tenn., was named southeastern district sales manager covering the southeast from the Mississippi River to the Atlantic Coast. He will be

a metal ball
PROBLEM?



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Work It Out For You

Whether it is a precision ball bearing or one of the other many ball applications in industry, your problem will not be entirely new. Strom has been in on many ball problems and knows the importance of the right ball for the job.

Strom has been making precision metal balls for over 25 years for all industry and can be a big help to you in selecting the right ball for any of your requirements. In size and spherical accuracy, perfection of surface, uniformity, and dependable physical quality, there's not a better ball made.

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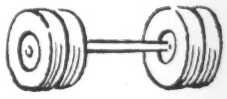
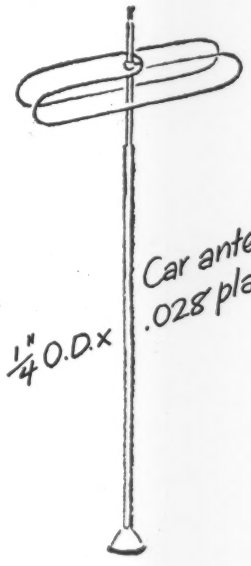
STEEL BALL CO.
1850 So. 54th Ave., Cicero 50, Ill.
Largest Independent and Exclusive Metal Ball Manufacturer

# Bundyweld "Doodles"

## to jog a designer's imagination

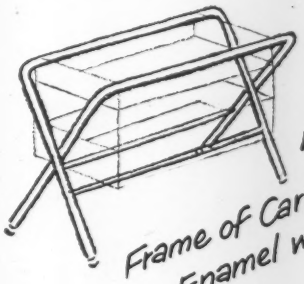


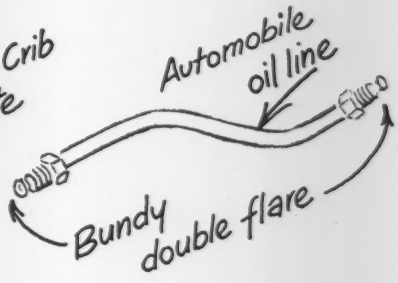
Toy truck axles ✓




**Redesigning** to get better tubing function? Want smoother, easier fabrication? Need engineering help to crack tough tubing problems?

Then check into Bundyweld, the *only* tubing double-walled from a single strip, with inside and outside beveled edges. And check into the Bundy engineering services that have already helped hundreds of Bundy customers to save money, time, materials. Let us send you the information you need. ***Bundy Tubing Company, Detroit 14, Mich.***




# Bundyweld® Tubing

**DOUBLE-WALLED FROM A SINGLE STRIP**

**High thermal conductivity**
**High bursting point**
**Leakproof**
**High endurance limit**
**Extra-strong**
**Shock-resistant**
**Ductile**
**Lightweight**
**Machines easily**
**Takes plastic coating**
**Scale-free**
**Bright and clean**
**No inside bead**
**Uniform I.D., O.D.**

**WHY BUNDYWELD IS BETTER TUBING**

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

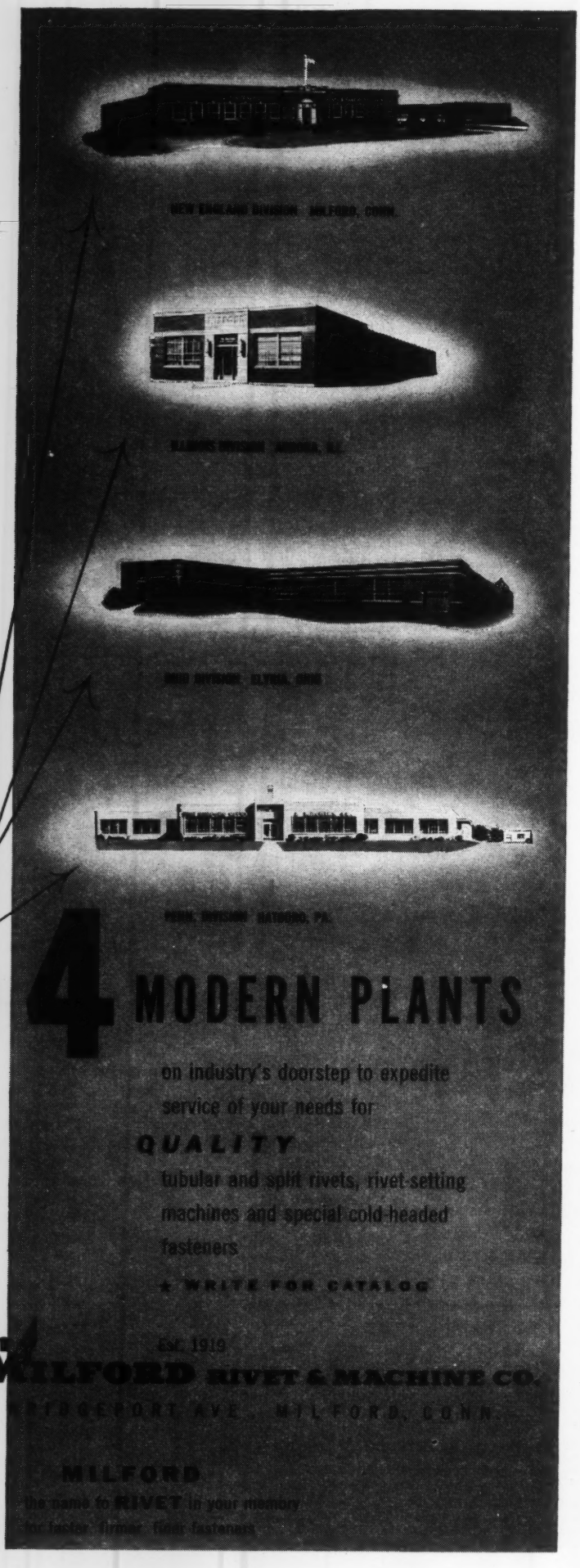
continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Presto . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

**Bundy Tubing Distributors and Representatives:** ***Cambridge, 42, Mass.:*** Austin-Hastings Co., Inc., 226 Binney St. • ***Chattanooga 2, Tenn.:*** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • ***Chicago 32, Ill.:*** Lapham-Hickey Co., 3333 W. 47th Place • ***Elizabeth, New Jersey:*** A. B. Murray Co., Inc., Post Office Box 476 • ***Philadelphia 3, Penn.:*** Rutan & Co., 1717 Sansom St. • ***San Francisco 10, Calif.:*** Pacific Metals Co., Ltd., 3100 19th St. • ***Seattle 4, Wash.:*** Eagle Metals Co., 4755 First Ave. South ***Toronto 5, Ontario, Canada:*** Alloy Metal Sales, Ltd., 881 Bay St. • **Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.**




headquartered in Memphis. **Frank E. Cavanaugh** has been added to Mr. Link's staff as a factory representative. **Joseph Van Schaik,** formerly with the home office, has been named factory representative in the Rocky Mountain states with headquarters in Denver, Colo. **Wayne E. Law,** formerly in the company's Houston, Tex., office, is now oil field factory representative in the Rocky Mountain states with headquarters in Denver, Colo.

♦

**Fred H. Kroeger** was recently named sales manager in charge of power brakes and devices for the Marvel-Schebler Products division of Borg-Warner Corp., Chicago.

♦

Associated with the company for 24 years, **A. F. Matheis** has been appointed assistant sales manager of industrial rubber products at Thermoid Co., Trenton, N. J.

♦

**Norman M. Godfrey** has been appointed manager of the eastern sales division of Hewitt-Robins Inc., New York. He will supervise sales in the Boston, New York, Philadelphia, Pittsburgh and Charleston, N. C., districts. **G. V. Migula** has joined the company as manager of the western sales division with headquarters at San Francisco. He replaces **J. H. Hayden,** who is retiring but will continue to serve in an advisory capacity. **Marion D. Austin,** who has been with the company since 1947, has also joined the western sales division as district manager of the Hewitt Rubber division. Mr. Austin has been manager of hose sales and development in Buffalo and is replaced in that position by **K. L. Way,** who has been a member of the product sales department for 23 years.

♦

Associated with the firm for 18 years, **Carlton H. Winslow** has been elected vice president in charge of sales of The Cuno Engineering Co., Meriden, Conn. He formerly served as assistant general manager.

♦

**Frederick W. Reynolds Jr.** recently joined the application engineering staff of the New York office of the Sprague Electric Co.

# FACT:

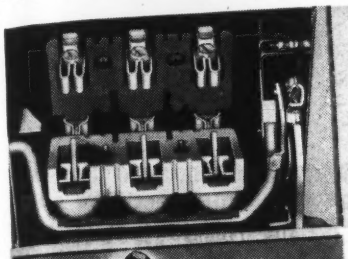
*Square D Type A Safety Switches are the overwhelming first choice of industry*

# REASON:

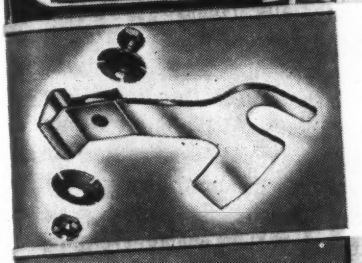
## DESIGN LEADERSHIP

# PROOF:

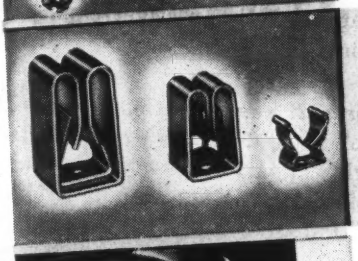
## *a feature-by-feature comparison*



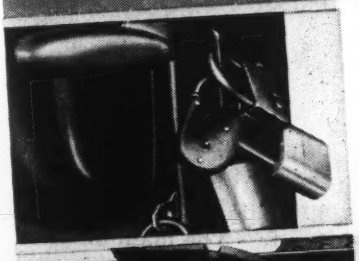
**Magnetic Arc Suppressors**
"blow out" the arc, contribute to exceptionally high interrupting capacity.



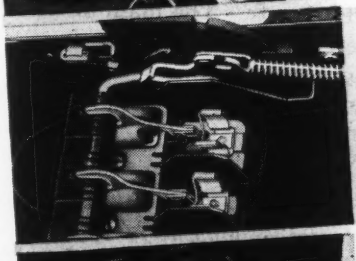
**Spring-Loaded Blade Hinges**
for pressure contact. **Silver plated** current-carrying parts. Not flash plated but completely plated to reduce temperature rise.



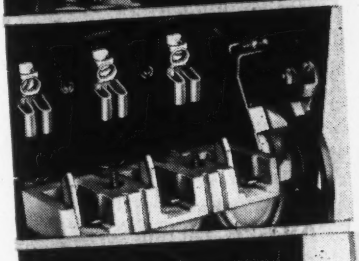
**Positive Pressure Fuse Clips**
reduce heating at fuse contacts 60% or more.



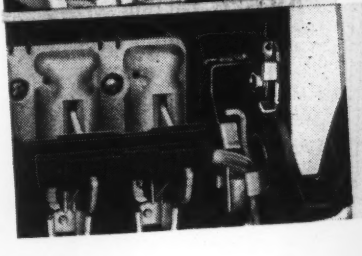
**Padlock Attachment**
locks switch "ON" or "OFF" with 1, 2, 3 or 4 padlocks of virtually any shape or size.



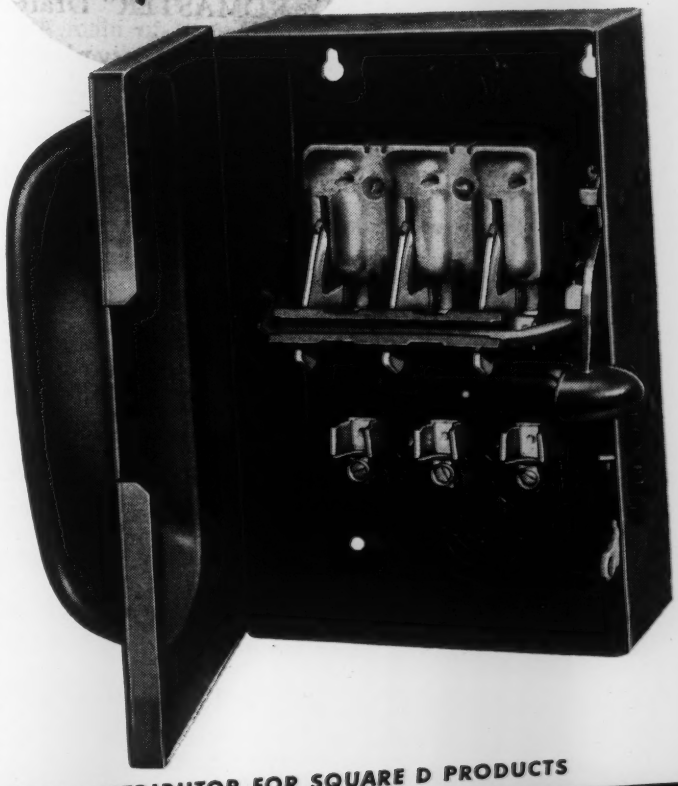
**True Quick-Make, Quick-Break**
Mechanism design makes it impossible to retard or to "tease" the operation.



**Dead Front**
construction. All exposed parts are dead when switch is in "OFF" position. **Hinged Arc Barrier** makes it easy to reach line terminals.



**Full Cover Interlock**
Switch cover can be opened or closed by authorized personnel without removing parts or interrupting service.



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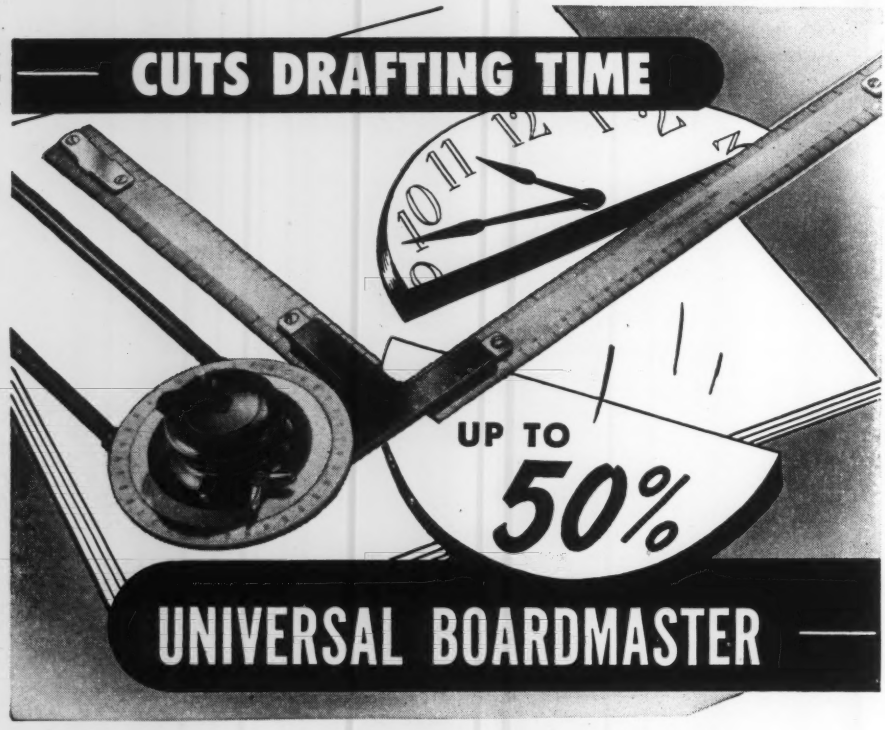



Industry's costliest commodity—Time—can be cut up to 50% on virtually every drafting job by the use of a Universal "BOARDMASTER" Drafting Machine.

"BOARDMASTER" permits easy placement of paper — adjusts quickly to base line — requires only one hand for its "turret control" of all operations — declutters the board of scales, triangles and protractors. It moves easily — maintains parallelism — and, when equipped with the new Universal Duraline scales, will not smudge the paper. And it can be adjusted in the field to any board angle.

Even if your boards are now machine equipped, it will pay you to compare what you are using with the Universal "BOARDMASTER." The difference in results will quickly prove the time and money savings that can be effected by up-grading your board equipment.

***Write today for Descriptive Literature on "BOARDMASTER" drafting machines and standard "DURALINE" scales.***

**UNIVERSAL DRAFTING MACHINE CORPORATION**
**7960 Lorain Avenue • Cleveland 2, Ohio**

**UNIVERSAL**
DRAFTING MACHINE
DURALINE SCALES


# SALES Notes

PRODUCTION engineering and sales of selenium rectifiers and tantalum electrolytic capacitors have been formally integrated into the new rectifier-capacitor division of **Fansteel Metallurgical Corp.**, North Chicago, Ill. Glen Ramsey, who for several years has been manager of the company's rectifier division, has been named general manager of the rectifier-capacitor division.

♦

**Aircraft Products Co.** has moved its plant and offices from Clifton Heights, Pa., to a newly constructed building at King Manor, Bridgeport, Pa.

♦

**Ampco Metal Inc.,** Milwaukee, recently announced the appointment of **Upton, Bradeen and James Ltd.** of Canada as an exclusive distributor of its resistance welding tips, dies, holders, rods, bushings, wheels, etc. The main office of the new representative is located in Toronto, Ont., and there are branches in Moncton, N. B.; Montreal, Que.; Ottawa, Hamilton and Windsor, Ont.; Winnipeg, Man.; and Vancouver, B. C.

♦

Opening of a new regional sales office and warehouse building at 732 Ashby St., N. W., Atlanta, Ga., has been announced by **Minnesota Mining & Mfg. Co.,** St. Paul.

♦

**Airtron Inc.,** designer and producer of aircraft and electronic components, has transferred its administrative offices to larger quarters at 20 East Elizabeth Ave., Linden, N. J.

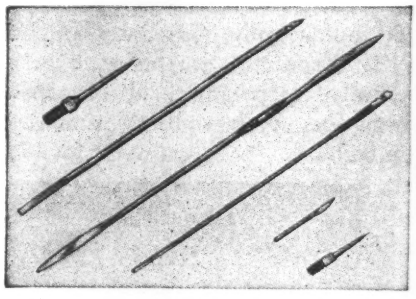
♦

The formation of a new south-central sales division has been announced by **Hewitt-Robins Inc.,** New York. With headquarters at Houston, Tex., the new division covers Texas, western Tennessee, Oklahoma, Arkansas, Louisiana, Mississippi and Alabama. The company has also announced the

# CUT COSTS

have your metal parts precision-made by

# TORRINGTON



Special equipment and volume production enable us to make precision parts for you at much lower costs.

For example, highest quality special needles for textile, leather, paper, etc., machinery. Pins for printing presses and surveyors' instruments. Special equipment assures proper heat-treatment . . . accurately formed eyes, grooves and shanks . . . precisely sharpened points . . . clean milling, knurling, slotting, and bevelling. Needles hand-straightened.

We are also set up to make such parts as knurled mandrels and spindles, screw driver and ice pick blades, instrument shafts and pivots, surgical and dental instruments, pen and pencil barrels, special rollers, studs, dowel pins, etc.

Send your prints and specifications today for a prompt quotation.

**THE TORRINGTON COMPANY**
*Specialty Department*
553 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS


removal of its Philadelphia office and warehouse from 401 North Broad St. to Coral and Hagert Sts., Philadelphia 25.

♦

**Electronic Rubber Co.,** Stamford, Conn., recently announced that its facilities are being expanded to include the manufacture of polyvinyl chloride injection molding and extrusion compounds for nonelectrical uses.

♦

**Sprague Electric Co.,** North Adams, Mass., has announced the opening of an application engineering office at 3 East Second St., Dayton, O. William M. Lana, formerly a member of the headquarters application engineering staff, will be in charge of the new office.

♦

In order to expand service facilities, headquarters of **Burndy Engineering Co. Inc.,** electrical connector manufacturer, have been moved into a new building in Norwalk, Conn.

♦

**Taylor Fibre Co.,** with main offices in Norristown, Pa., and La Verne, Calif., has announced the opening of a new district office located at 822 Wood St., Pittsburgh 21, Pa. W. H. Slocum is the district manager of this office, which will serve the Pittsburgh area with Taylor's line of vulcanized fiber, phenol, silicone and melamine laminates.

♦

A new southwestern branch office has been opened by Naugatuck Chemical Division of **United States Rubber Co.,** New York, for the sale of rubber and plastic latices used in paints, adhesives, etc. Located at 1480 North Thomas St., Memphis, Tenn., the new branch will cover the territory of Kansas, Missouri, Texas, Arkansas, Louisiana, Mississippi, Alabama, the southern portion of Illinois and Indiana, and western sections of Kentucky and Tennessee. Included in the line of products to be handled by the new branch are: natural and synthetic rubber latices; compounded, ready-to-use latices known as Lotols; water dispersions of reclaimed rubber or plastics known as Dispersite; high styrene plastic latices known as Kralac.

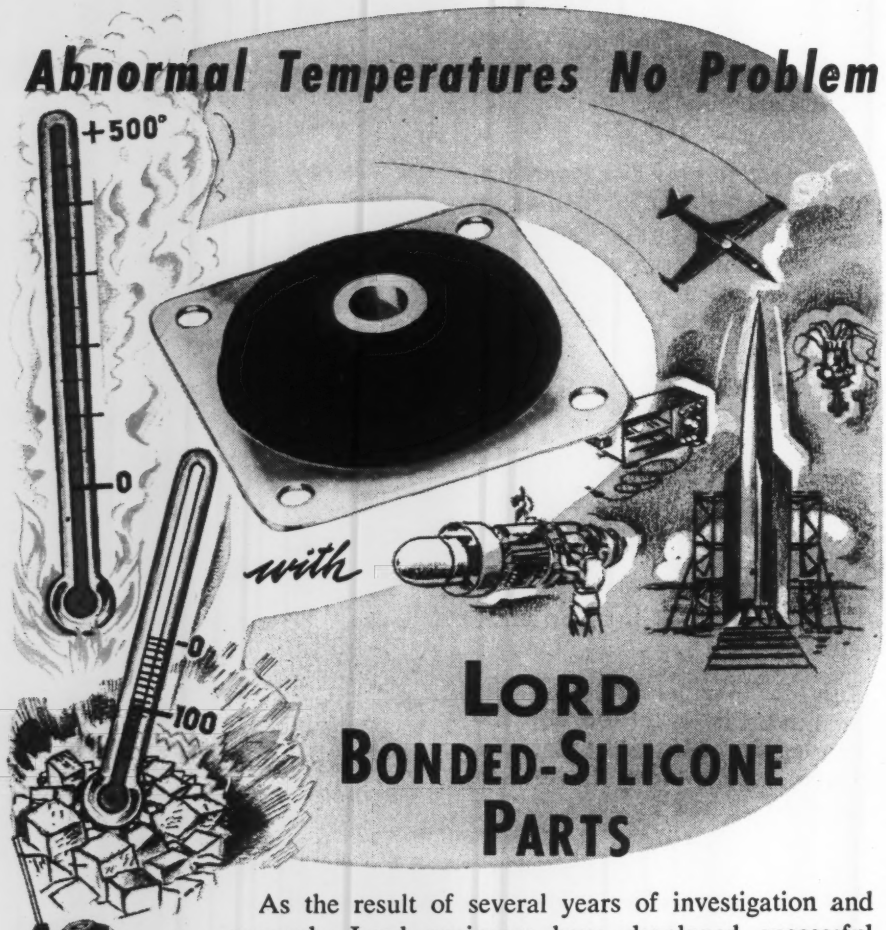
When the **AXLE** COUNTS . . .
SPECIFY
**CARAVAN!**

United CARAVAN axles provide **dependable mobility** for all types of portable equipment. These versatile units can be used on compressors, fire-fighting apparatus, pumps, concrete mixers, welders, generators, etc. as well as many types of military equipment.
CARAVAN axles can be furnished in two-wheel, single-axle assemblies and as four-wheel running gear equipped with automotive type steering mechanisms. Straight and drop axle type construction is available.
CARAVAN axles are engineered to assure smooth movement over high grade surfaces and maximum roadability over rough terrain. Controlled camber, toe-in and caster provide positive trail, regardless of speed or road conditions.
Write today for 12-page illustrated Catalog No. 101 containing specifications on the complete line of CARAVAN axles and describing automatic surge-control braking device, retractable third-wheel assembly and other CARAVAN accessories.

430 UM

The UNITED MANUFACTURING CO.
314 W. Interstate St. • Bedford, Ohio

# Abnormal Temperatures No Problem




As the result of several years of investigation and research, Lord engineers have developed successful techniques for bonding silicone to metal. This extends the advantages of bonded rubber into the wider temperature range from —100° to +500°F.

A number of Lord Vibration-Control Mountings are available with silicone elastomers, and new designs are being engineered to take full advantage of the properties of this new material.

You can solve many product problems with Lord bonded-silicone parts which are used to isolate vibration and reduce operating noise, and protect parts from excessive stresses.

***The easiest way to get the full story of the advantages of LORD BONDED SILICONES is to write or call . . .***

**BURBANK, CALIFORNIA**
Joe B. Hartley
George E. Behlmer
233 South Third Street
ROckwell 9-2151
CHarleston 6-7481

**CHICAGO 11, ILLINOIS**
Robert T. Daily
Kenneth L. Hanson
Perry C. Goodspeed, Jr.
520 N. Michigan Ave.
MIchigan 2-6010

**DALLAS, TEXAS**
Bruce O. Todd
1613 Tower Petroleum Building
PRospect 7996

**DAYTON 2, OHIO**
W. Webster Dalton
238 Lafayette Street
MIchigan 8871

**DETROIT 2, MICHIGAN**
Everett C. Vallin
7310 Woodward Ave.
TRinity 5-8239

**NEW YORK 16, NEW YORK**
Vincent Ellis
Jack M. Weaver
280 Madison Avenue
MUrray Hill 5-4477

**PHILADELPHIA 7, PENNSYLVANIA**
George P. Harrington
725 Widener Building
LOcust 4-0147

**ERIE, PENNSYLVANIA**
Paul E. Dailey
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1635 West 12th Street
2-2296

**LORD MANUFACTURING COMPANY • ERIE, PA.**

LORD BONDED RUBBER

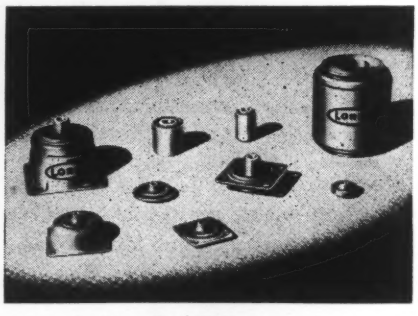
HEADQUARTERS FOR
VIBRATION CONTROL MOUNTINGS
. . . BONDED RUBBER PARTS


ADVERTISEMENT

## Silicones Bonded to Metal Improve Product Operation at Extremes of Temperature

The new field of organosilicon chemistry has produced silicone rubber which is thermally stable. Translated in terms of work for practical application in industry, silicone rubber maintains resiliency and provides maximum isolation of shock and vibration at such extreme temperatures as —100°F and +500°F.

Going a step farther silicone rubber molded into useful forms opens up a wide field of value to the designer of industrial products. For example, the bonded-silicone vibration control mountings and bonded-silicone parts produced by the Lord Manufacturing Company of Erie, Pa. Especially is this true in the vitally important field of modern aviation, both military and commercial.



Lord Bonded-Silicones have excellent dielectric characteristics and their chemical stability permits use under most atmospheric and chemical conditions with no danger of decomposition.

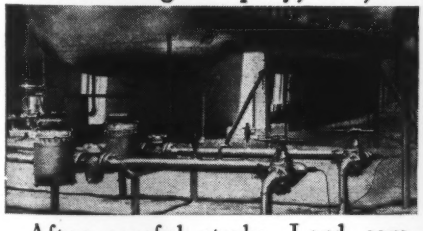
Heretofore the highest efficiency of other elastomers was limited by a temperature range of —80°F and +170°F. The hardening of ordinary rubbers at the above low temperature and their deterioration at the high, posed a problem for Lord Engineers which finally found its solution in the application of silicone compounds. Lord Bonded-Silicones are now in service on aircraft nacelle mounted equipment and airborne electronic equipment as vibration isolation mountings. Lord Bonded-Silicone parts are also used as turbo-jet bearing seals, commutator spring bumper pads, on fire detectors and on diesel equipment operating at extremes of temperature. The high resistance to moisture of bonded-silicones suggests many practical uses as yet in the experimental stage.

ADVERTISEMENT

## Specialized Elastic Material Seals Vapor-Tight Valve

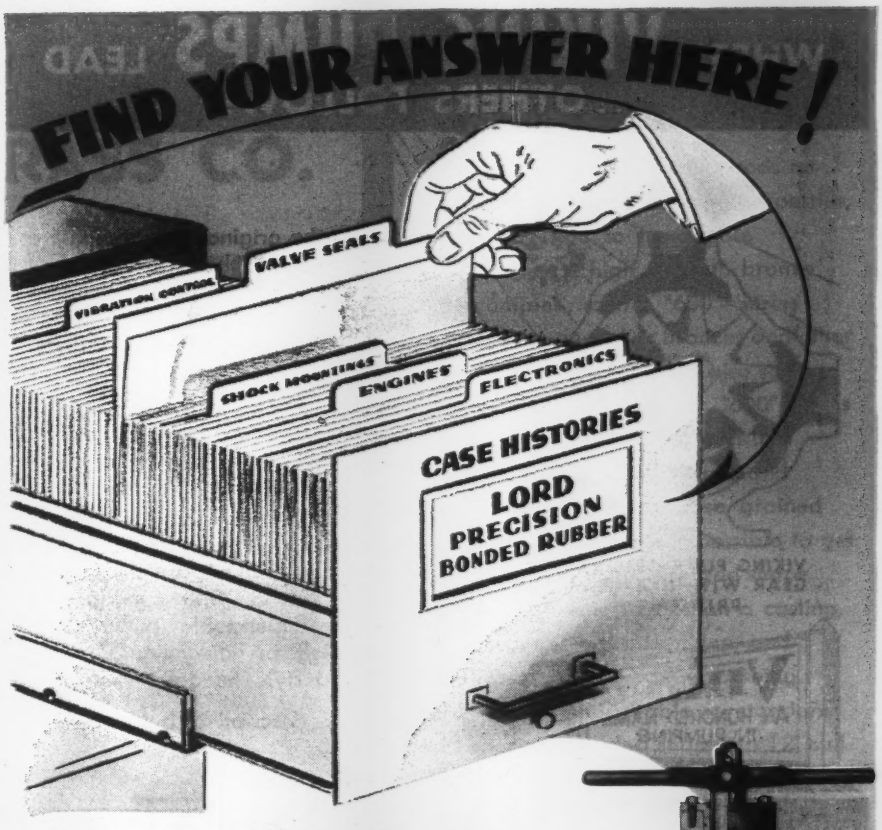
Among the many manufacturers who have improved the performance of their products through the use of specialized elastic compounds is Kerotest Manufacturing Company, Pittsburgh, Pa. Their recently announced General Twin-Seal Valves employ a tapered plug between two elastic-surfaced "slips". These slips are made of corrosion resistant metal with specialized elastic material permanently bonded to the surfaces which come into contact with seats of the valve. The first full turn of the control wheel raises the tapered plug and withdraws the slips from their seats until approximately .040" clearance results. The next quarter turn of the wheel revolves both tapered plug and slips to line up the plug ports with those of the valve body.

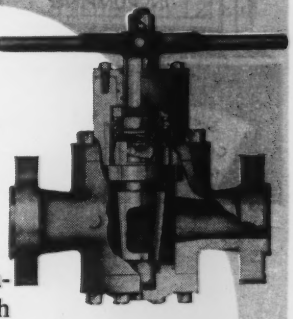
During the early stages of development and test of these new valves, considerable difficulty was encountered in finding a type of elastic coating for the slips which would withstand attack by salt water, gas, and highly-volatile hydro-carbons; and which would also retain its resiliency under repeated applications of pressure. At this point, the problem was placed with Lord Manufacturing Company, Erie, Pa.



After careful study, Lord compound #E-3425 was recommended. This compound has a Buna-N Base, and is particularly resistant to abrasive wear and swelling. Furthermore, #E-3425 lends itself well to the formation of a high-strength bond with the metal part of the slip.

Performance records have been highly satisfactory since Lord compound #E-3425 was adopted as standard for the resilient surfacing of all Kerotest valve slips. As the result of this intelligent analysis Kerotest General Twin-Seal Valves are furnishing the petroleum industry, marine industry, and other industrial valve users with a type of service previously unavailable in plug valves.

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*Profitably!*

The manufacturer of Kerotest General Twin-Seal Valves needed bonded-rubber seals which would not peel or disintegrate in contact with volatile petroleum products. The problem was placed with Lord. The answer was found immediately in a specialized compound which Lord engineers had already developed for another valve seal requirement . . . the toughest, longest lasting, precision contoured seal yet known.

Your product may be improved by using Lord bonded-rubber parts . . . the easiest way to control vibration and reduce operating noise. You can find dependable, profitable answers to help you among the many Lord case histories of successful bonded-rubber applications.

***For immediate attention to your problem call or write***

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HEADQUARTERS FOR
VIBRATION CONTROL MOUNTINGS
. . . BONDED RUBBER PARTS

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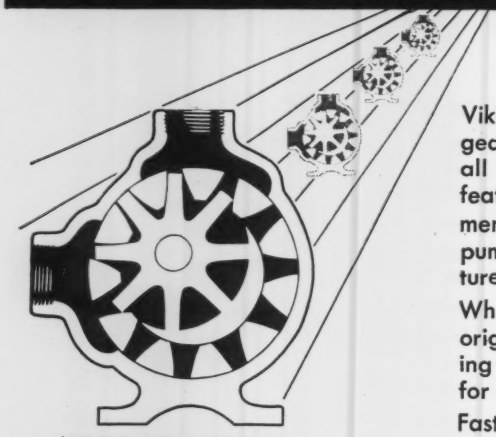
... OTHERS FOLLOW!



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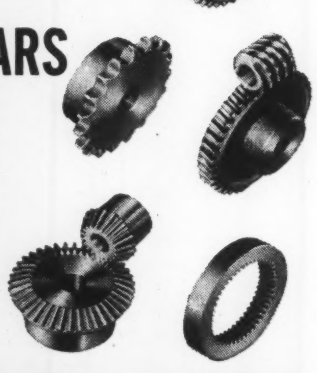

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PERFECTION GEAR COMPANY • HARVEY, ILLINOIS


# Meetings

## AND EXPOSITIONS

**Mar. 17-19—**

**Midwestern Conference on Fluid Mechanics.** Second conference to be held at Ohio State University, Columbus, O. Additional information may be obtained from Professor Geoffrey Keller, conference secretary.

**Mar. 17-21—**

**American Society of Tool Engineers.** Twentieth annual meeting and industrial exposition to be held at the International Amphitheatre in Chicago, Ill. Harry E. Conrad, 10700 Puritan Ave., Detroit 26, Mich., is executive secretary.

**Mar. 18-19—**

**Steel Founders' Society.** Annual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 920 Midland Bldg., Cleveland, O.

**Mar. 20-21—**

**Pressed Metal Institute.** Third spring technical meeting to be held at Hotel Carter, Cleveland, O. Orrin B. Werntz, 13210 Shaker Square, Cleveland, O. is managing director.

**Mar. 22-Apr. 6—**

**International Trade Fair.** Second trade fair to be held at the Navy Pier in Chicago, Ill. John N. Gage, Colonel, U. S. A. (Ret.), 10316 Merchandise Mart, Chicago 54, Ill., is executive vice president.

**Mar. 24-26—**

**American Society of Mechanical Engineers.** Spring meeting to be held at the University of Washington, Seattle, Wash. C. E. Davies, 29 West 59th St., New York, N. Y., is secretary.

**Mar. 26-28—**

**American Power Conference,** formerly Midwest Power Conference, sponsored by the Illinois Institute

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# "600" SERIES

## a better bearing bronze containing no-hard-to-get tin

If you use gears, connecting rods or other parts requiring bearing properties, it will pay you to investigate "600" Series, a high strength bronze that *contains no tin.* "600" Series outperforms phosphor bronzes and other bearing metals . . . it will also save time, money, and material. "600" Series bearing metals can be forged into relatively complicated shapes and produce a forging of close-grained homogeneous structure impossible to get in a sand casting. The forged shape is closer to finished size than a casting, often requires less machining, and eliminates the need of a bushing. "600" Series is available in standard and special extruded shapes in 12′ mill lengths. These alloys have a low coefficient of friction, a tensile strength 2½ times greater than cast phosphor bronzes and high resistance to corrosion. There is a "600" Series alloy with the properties to fit your bearing metal need...write today for further facts.

Typical forged parts and rod shapes produced from Mueller Brass Co. "600" Series bearing bronze

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# MUELLER BRASS CO.

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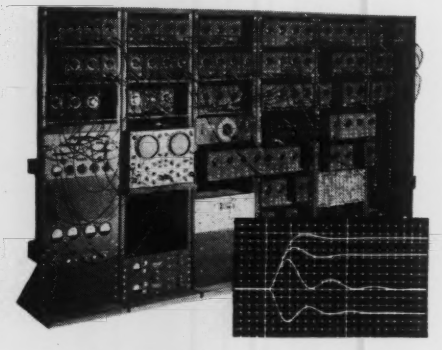
HOW YOU CAN "BUILD" AN AUTOMATIC ELECTRONIC

**Analog Computor**

WITH THE GAP/R SERIES OF

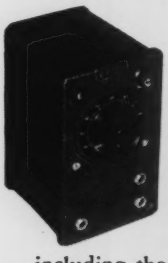
**Components**



Perhaps you need an assemblage this size for solving 36th-order differential equations, or possibly the equipment in the left-hand rack alone will suffice. In either case your "building blocks" are provided by our standard *Computing Components*, of which two examples are illustrated below. Here, for example, is

MODEL K4-DY

This Component is one of 5 in the K4 Series. Called the *Dynamic Component*, it embodies a 2nd-order linear operator with all parameters adjustable. Also available: the double *multiplier*, the *controller*, and two completely flexible components for *non-linear functions*. More elementary, but highly versatile, operations are incorporated in the Components of the K3 Series, such as



MODEL K3-E

This is an *Augmenting Differentiator*, which performs a 1st-order linear operation having one adjustable parameter. There are 12 other models in this same size, including those for such other linear operations as *addition, integration, retardation*, and for setting *coefficients*. Examples in the non-linear class are Components for *bounding, squaring*, and computation of *absolute value*.

Investigate!

These little "black boxes", and the computing systems easily assembled from them, can magnify your brainpower and diminish your time scales They are fast, accurate, economical, and ready & willing to work (on *your* problems).

George A. Philbrick Researches, Inc.
230 Congress Street, Boston 10, Mass.

of Technology to be held at the Sherman Hotel, Chicago, Ill. Additional information may be obtained from Dr. R. A. Budenholzer, Director of the Conference, 3300 Federal St., Chicago 16, Ill.

**Mar. 30-31—**

**Packaging Machinery Manufacturers Institute.** Semiannual meeting to be held at the Hotel Dennis, Atlantic City, N. J. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

**Apr. 1-4—**

**American Management Association.** The 21st national packaging exposition to be held in the Atlantic City Auditorium, Atlantic City, N. J. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 18, N. Y.

**Apr. 7-9—**

**American Society of Lubrication Engineers.** Annual meeting to be held at the Statler Hotel, Cleveland, O. W. F. Leonard, 343 South Dearborn St., Chicago 4, Ill., is national secretary.

**Apr. 9-11—**

**Society of the Plastics Industry.** Seventh annual technical session of the Reinforced Plastics Division to be held at the Edgewater Beach Hotel, Chicago, Ill. W. T. Cruse, 295 Madison Ave., New York 17, N. Y. is executive vice president.

**Apr. 21-24—**

**Society of Automotive Engineers.** Aeronautic, aircraft engineering display and technical air review to be held at the Statler Hotel, New York, N. Y. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

**Apr. 29-30—**

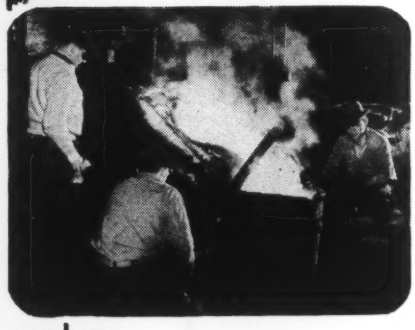
**Metal Powder Association.** Eighth annual meeting and exhibit to be held at the Drake Hotel, Chicago, Ill. Additional information may be obtained from association headquarters, 420 Lexington Ave., New York 17, N. Y.

**Available**

*for the first time...*

***a Full-Color Sound Film***

**STEEL WITH A THOUSAND QUALITIES**



Scientific schools and groups of designers,engineers, metallurgists and technical societies can *now* secure the *free* use of this full-color sound film, the first produced in the steel foundry industry. Available in 16 mm prints, the film is a 37-minute tour of the modern plant of Lebanon Steel Foundry. The camera follows jobs from the blueprints on the project engineer's desk through steps of production to show, finally, a few of the many important uses of Lebanon quality Steel Castings. Write for information on this exciting and educational film.

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# Not One at a Time But All At Once

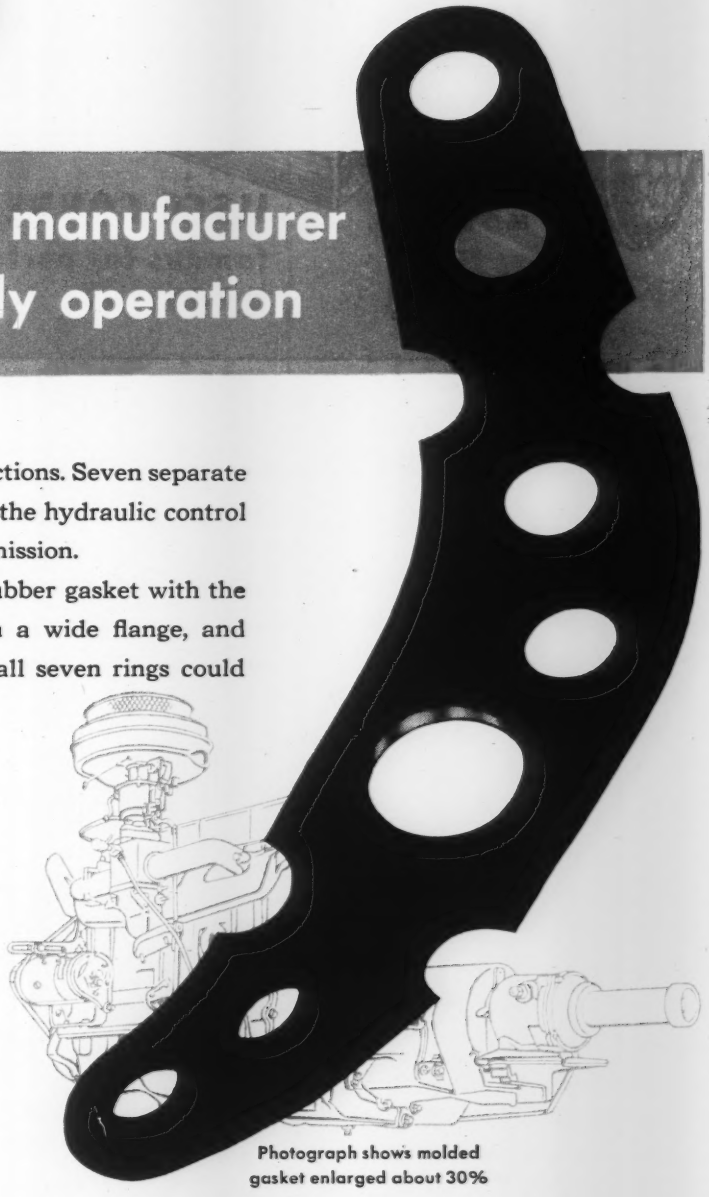
## Here's how one motor manufacturer simplified an assembly operation

Formerly, it was like putting on a glove—in sections. Seven separate synthetic rings had to be inserted in 7 ports in the hydraulic control mechanism, the heart of the automatic transmission.

The obvious answer called for a synthetic rubber gasket with the 7 square-shoulder rings molded integral with a wide flange, and located exactly opposite each port — so that all seven rings could be installed simultaneously.

Producing this special packing, with a wide flange held to .030″ ± .005″, was one of those "impossible" molding operations that merely takes a little longer.

The result is a typical example of how G&K-INTERNATIONAL engineering and manufacturing are helping industry solve problems in pneumatic and hydraulic packings applications.



Photograph shows molded gasket enlarged about 30%

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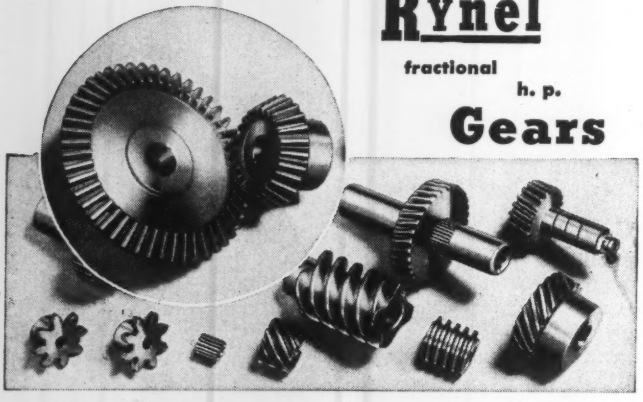


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# New Machines

## Domestic

**Washers:** Three models of agitator-type action, wringer machines. Deluxe model AW-472 takes a 10-lb load of dry clothes and 19 gal of water. Has roll-type wringer which stops when pushed or pulled or when tugged on by clothes going through. Balloon rolls automatically adjust themselves to thickness of garments. Timer regulates washing period up to 15 min. Model AW-372 has tub capacity of 8 lb of dry clothes and 17 gal of water. Features one-control wringer, adjustable timer and finger-tip wash and drain control levers. Model AW-172 has wringer of one-control type with self-adjusting rolls and a pressure release bar. *Major Appliance Division, General Electric Co., Louisville, Ky.*

**Food Freezer:** Incorporates all major features of earlier models but is 1 ft narrower in width. Natural draft condenser cooling has made possible the combining of freezing mechanism and freezer into a single integrated unit without affecting storage capacity or depth. Freezer has capacity of 389 lb and can fast-freeze up to 60 lb of food in 24 hrs. Has counterbalanced lid, adjustable temperature control, automatic interior lighting, and outside signal light to indicate proper functioning. *Major Appliance Division, General Electric Co., Louisville, Ky.*

## Metalworking

**Straightening Press:** Hydraulic unit for sensitive work. Features automatic stroke limiter to protect against overbending. Controlled through vertical shifter rod operated by hand lever. In shifting the rod up or down, fluid volume from a variable-displacement pump is increased or decreased in proportion to lever movement. A stop attached to the rod is engaged by the descending ram, gradually re-

NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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# PROPER DESIGN IN WELDED STEEL IMPROVES PRODUCT

## . . . cuts costs for Hanson-Van Winkle-Munning

THE examples show how one prominent manufacturer has improved the quality of his products while cutting costs by converting to welded steel design.

When designing for efficient welded steel construction, savings in initial material cost alone generally average 85% to 95%. This is because steel costs less per pound. And with steel's greater strength and rigidity, fewer pounds of metal are needed. In many cases, machining operations required for iron can be minimized or eliminated entirely.

Where product designs utilize the economies of welded steel, cost analyses show that:

**1.** Material costs for steel generally range from 5% to 15% as compared with castings.

**2.** Labor costs for fabricating steel are about 30% of initial casting purchase costs.

**3.** Welding costs average 50% of total labor costs for fabricating steel.

If your costs do not approximate these averages, your product designs should be reappraised. A Lincoln Welding Engineer will gladly point out what benefits of welded steel may have been overlooked.

**Inquire about the "Weldesign Training Course" for your engineers, designers and production men.**



**Fig. 3. Welded steel** *saves 30% cost . . . cuts weight 50%. Design is simpler . . . plain channel replaces complicated casting.*



**Fig. 4. Stronger, more rugged machine part** *results when fabricated from steel strip and standard channel. Weight is cut from 3 lbs. to 2 lbs. 4 oz. Cost of this small part is 12% less.*

## ORIGINAL CONSTRUCTION



**Fig. 1. Machine bracket** *for* **Hanson-Van Winkle-Munning,** *Matawan, N.J. weighed 50% more than present steel design. Casting had to be left heavy for strength in hub and arm. Design made efficient use of cast iron by providing cored slots. Casting required milling and drilling.*

## PRESENT WELDED STEEL DESIGN



**Fig. 2. Finished weldment** *costs 25% less . . . eliminates former breakage experienced in casting. Steel hub, cut from bar stock and pre-drilled, is welded to simple formed steel arm in which holes are pre-punched.*

**MORE SAVINGS**

*Machine Design Sheets are available to designers and engineers. Write on your letterhead to Dept. 13,*

## THE LINCOLN ELECTRIC COMPANY

**CLEVELAND 17, OHIO**

*The World's Largest Manufacturer of Arc Welding Equipment*

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ducing pump discharge to zero, thereby halting the ram automatically at a predetermined position. Specifications: maximum daylight opening, 30 in.; minimum daylight opening, 10 in.; throat depth, 19 in.; table size, 21 by 108 in.; pressing speeds, 0-48 ipm; retracting speeds, 0-65 ipm. *Hufford Machine Works Inc., El Segundo, Calif.*

**Core Grinder:** Portable Model No. 18 employs 18-in. diameter grinding wheel mounted on an adjustable head which locks in any position. Maximum clearance between table and face of grinding wheel, 18 in., maximum working capacity, 15 by 24-in. core surface. Supplied with 1-hp 220/440-v fully enclosed motor which drives grinding wheel at 660 rpm. *SPO Inc., Cleveland, O.*

**Double Spindle Grinder:** For grinding both flat surfaces of carburetor valve seats in one operation. Has automatic feeder. Head slides move on ball bearing ways. Heads may be pivoted to set abrasive disks at various grinding angles. Abrasive disks 18 in. in diameter are carried on heavy precision spindles. Rotary work carrier supports parts between abrasives. From hopper feeder, parts pass down a chute where a pneumatic transfer device snaps them into the carrier. Parts are automatically ejected after grinding. Production averages 40 to 50 pieces per minute, removing 0.006 in. overall stock. Maintains tolerances of 0.0005 in. for flatness, 0.001 in. for parallelism and 0.001 in. for uniformity. *Gardner Machine Co., Beloit, Wis.*

**Self-Indexing Bed Turret:** For use on most standard lathes ranging from 9 to 12-in. swing. Features self - indexing mechanism linked to automatic stop rods which limit stroke length. Can be set for any requirement up to full slide working stroke of 5¼ in. Total slide travel, 6 in. Turret is guided in rotation by a large diameter, integrally-cast pilot which engages a mating bearing in the slide. Hexagonal turret provided with flat faces to accommodate flanged tool holders may be bored for straight shank tools. Indexing performed by spring-loaded tapered pin sliding in a sleeve and engaging a mating tapered bushing in

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# Specify this Fast-action Gate that seats tight and stays tight

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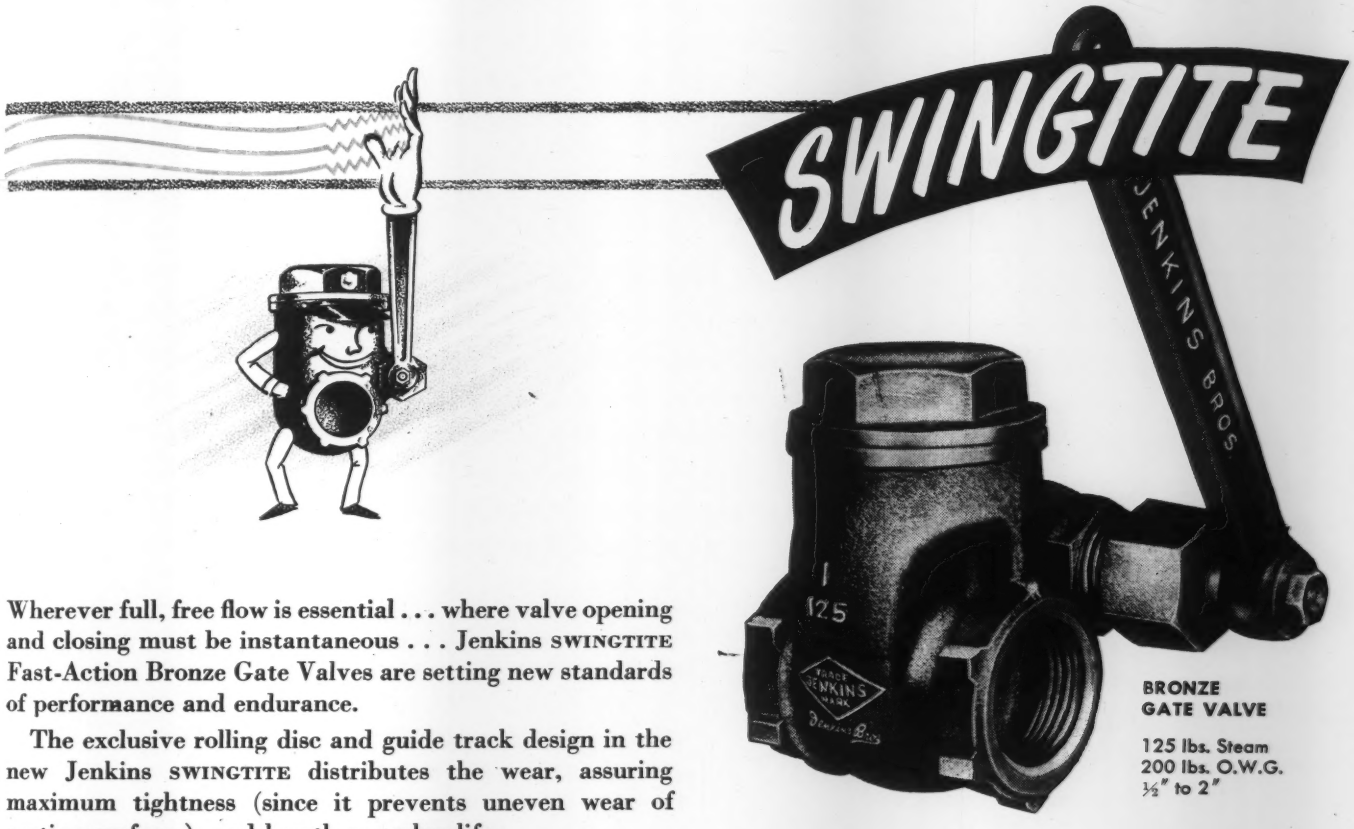


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125 lbs. Steam
200 lbs. O.W.G.
½" to 2"

Wherever full, free flow is essential . . . where valve opening and closing must be instantaneous . . . Jenkins SWINGTITE Fast-Action Bronze Gate Valves are setting new standards of performance and endurance.

The exclusive rolling disc and guide track design in the new Jenkins SWINGTITE distributes the wear, assuring maximum tightness (since it prevents uneven wear of seating surfaces), and lengthens valve life.

If you design any equipment requiring Fast-Action Gates, find out how Jenkins can help you make your product more efficient and dependable. Send for folder describing the new SWINGTITE Bronze Lever Gate Valve. You add sales-appeal to your product, too, when you specify the SWINGTITE. It's made by Jenkins Bros., a name your customers know and trust. Write today for Form No. 196. Jenkins Bros., 100 Park Ave., New York 17; Jenkins Bros., Ltd., Montreal.

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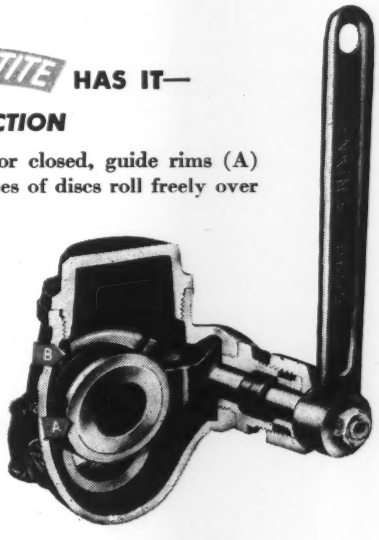
**ONLY THE SWINGTITE HAS IT—**

***ROLLER ACTION***

As the valve is opened or closed, guide rims (A) around the seating surfaces of discs roll freely over guide tracks (B) cast in the body, distributing wear evenly, dislodging foreign matter, and providing a polishing action for seating surfaces. This rolling disc and track construction lengthens valve life and assures maximum tightness.

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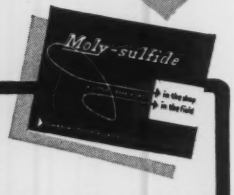


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MOLY

MD3 MS4


turret. Has calibrated scale showing length of stroke. Tool clearance over ram of 3½ in. on 9 and 10-in. lathe model and 4 in. on 11 and 12-in. model; five-spoke pilot wheel. *Globe Heat-Seal Inc., Los Angeles, Calif.*

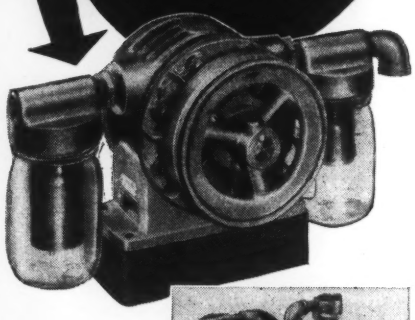
**Impregnating Equipment:** For production-line impregnating castings to seal porosity. Seals both leaking and weeping castings, ferrous and nonferrous, by use of high vacuum. Effective on castings with only minute porosity, fissures or pinholes. Castings are subjected to 29½-in. vacuum for 20 minutes to remove all air and moisture from voids. Impregnating solution is introduced into vacuum tank, followed by application of 100 psi air pressure for 20 minutes to force solution into casting walls. Solution is then withdrawn to storage tank, and castings are removed and rinsed in water. Capacity, 4½ cu ft; size of tank, 20 by 30 in.; floor space required, 36 by 100 in.; weight, 850 lb. *Metallizing Co. of America, Chicago, Ill.*

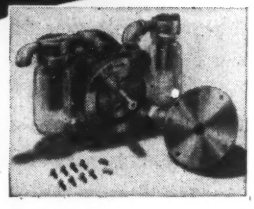
**Sander:** For sanding, wire brushing, grinding and polishing metal. wood, tile, plastic, glass, concrete and other materials. Features precision machined, heat-treated alloy steel gears, pinions and spindles; grease-sealed ball and needle bearings; easily accessible pigtail brushes for quick inspection or replacement. Universal motor designed for dc or ac 25-60 cycles. Rated at 5.5 amp at full load on 110-v current. Supplied with 7-in. flexible rubber pad, 7-in. semirigid Co-Ro-Lite pad and three 7-in. assorted cloth-backed sanding disks. Other accessories available. *Millers Falls Co., Greenfield, Mass.*

**Arc Welder:** Gasoline engine driven unit has control panel mounted at generator end of machine in order to centrally locate all controls for easier adjustment of welding current. Generator is of symmetrical, four-pole multirange design; has four laminated main poles and four interpoles which are removable. Welding current controlled by large control wheel and volt-amp adjuster within large wheel. Volt-amp adjuster provides 100 steps of fine adjustment in each of the ten main ranges. Prompt building up of voltage and freedom from acci-


**FORGET THE OIL!**

**GAST rotary Oil-less AIR PUMPS never need it!**





Above — Oil-less Model 1550 — 8 to 10 C.F.M.
Right — Oil-less Model 3040, end plate removed. From 17 to 24 C.F.M.

**Three things about these pumps are outstanding:**

**FIRST** — They run *entirely without oil* in the pumping chamber. Four carbon vanes in rotor lubricate themselves — through thousands of hours of operation. Ball bearings are greased and sealed for life. You can *forget* oiling problems!

**SECOND** — They completely eliminate oil-mist in the air delivered. Used for *both* vacuum and pressure they *can't* contaminate your product or material with oil droplets.

**THIRD** — They're built with traditional Gast precision — for years of high performance and dependability.

**IF THESE QUALITIES** offer solutions to your original equipment problems, write Gast. Oil-less models from 10 to 20 inches vacuum — 3 to 10 lbs. pressure — 3.5 to 24 C.F.M.

SEE OUR CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

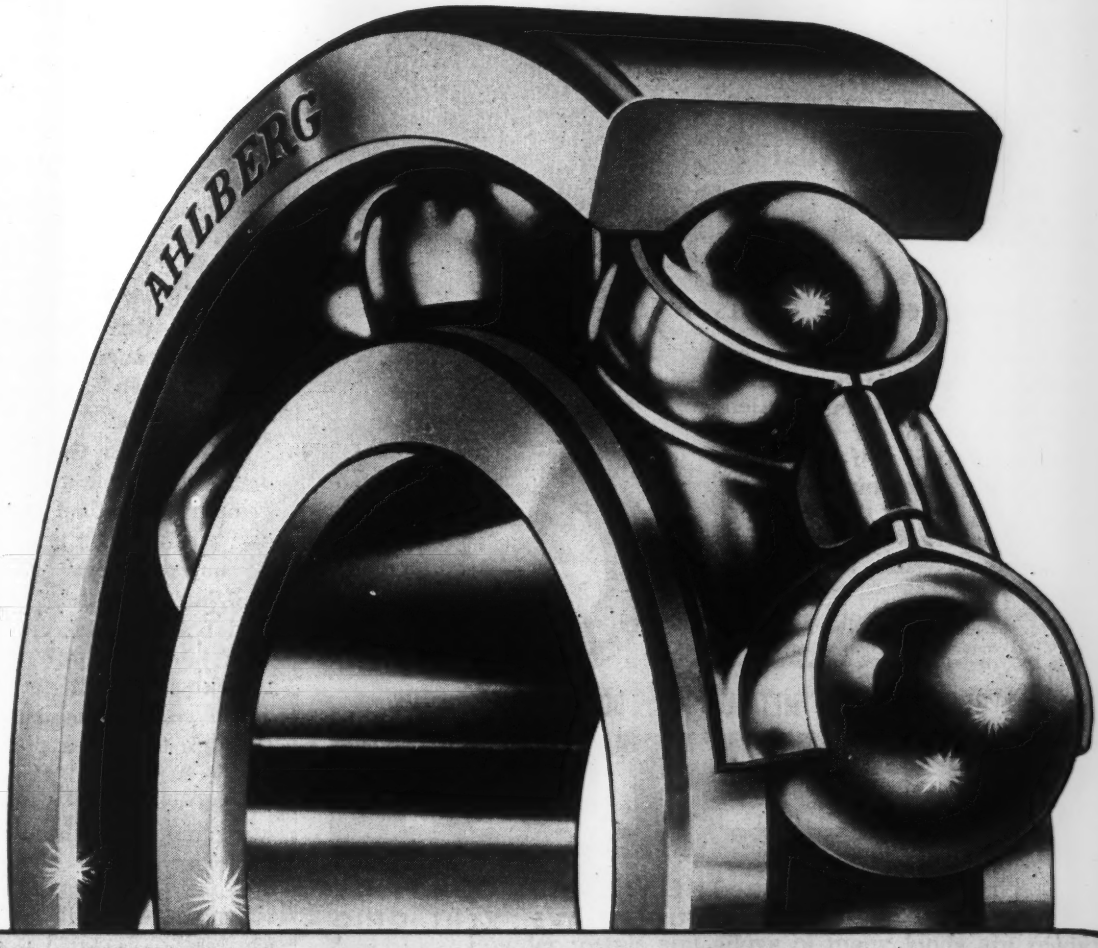
Write for new Data Sheet on Oil-less Pumps, showing 3 types and rating tables.

*Original Equipment Manufacturers for Over 25 Years*

GAST ROTARY

AIR MOTORS · COMPRESSORS · VACUUM PUMPS
(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)

GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.

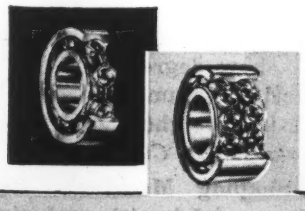


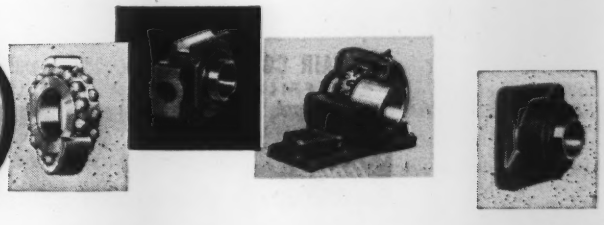

# KEEPING AMERICA'S MACHINES FIT FOR THE FIGHT!

Day by day the nation's defense requirements are attaching greater impetus to improvements in machine design. This trend not only affects military equipment, but also every kind of industrial machine that must be kept fit for the enormous production fight that lies ahead.

That's why RIGHT NOW is a good time to redesign the equipment you make or the equipment you use to include Ahlberg Precision Bearings at every vital point . . . to minimize friction, assure trouble-free operation, long life, low power consumption and compact equipment design.

Bringing such advantages to ANY machine speeds the security of our nation, the strength and well being of American business. Ahlberg Bearing Company, 3025 W. 47th St., Chicago 32, Illinois.





**AHLBERG**

PRECISIONEERED ANTI-FRICTION PRODUCTS SINCE 1908

# STARVING ?

**IS YOUR PLANT SUFFERING FROM A DEFICIENCY OF CRITICAL METALS**

No need for it—because there are *dependable* alternate materials. Take iron powder. It's doing an excellent job in place of copper powder in the production of self-lubricating bearings and machine parts. Because of the critical copper shortage, Wel-Met urges you to consider this conversion—and will be glad to help!

Retainer ring for textile machine. Made to close tolerances from iron powder. No machining. Costs 30% less than part replaced.

**FOR BETTER POWDER METALLURGY... DON'T FORGET... IT'S ...**

# WEL-MET

*Manufacturing Plants*
KENT, OHIO
SALEM, INDIANA

**THE WEL-MET COMPANY**
**122 GOUGLER AVE., KENT, OHIO**

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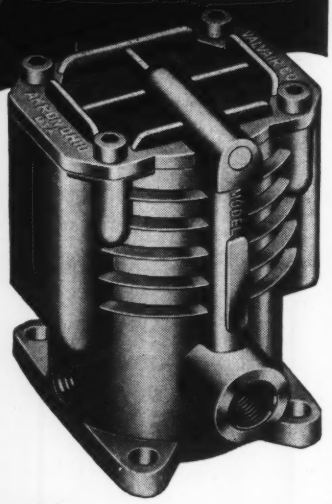
DESIGNERS' DREAM COME TRUE!

# The *New* VALVAIR SOLENOID PILOT VALVE



## *Outstanding Features*

**in a New Valve PRICED ATTRACTIVELY!**

- OVER 20,000,000 CYCLES
- CORROSION-PROOF
- NO OVERHEATING
- MANIFOLD MOUNTING AVAILABLE

SIZE: ¼" pipe tap, orifice ⅛" or 3/16".

*Write for new Bulletin D-3.*

The NEW Valvair Solenoid Pilot Valve is offered in 2-way and 3-way models, normally open or normally closed. Coils are completely sealed. Only two moving parts: spring and plunger. Valve life is almost unlimited.

**VALVAIR CORPORATION • 953 Beardsley Ave., Akron 11, Ohio**
**AFFILIATE: SINCLAIR-COLLINS VALVE CO.**

*Rely Upon* Valvair 2-WAY 3-WAY 4-WAY

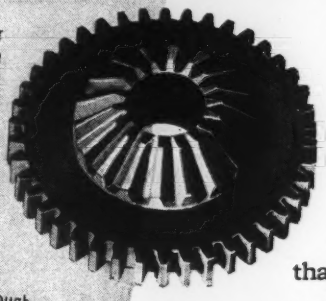

dental polarity reversal are assured by special oversize, inbuilt, four-pole exciter. Excess power from this exciter can be used to operate lights and portable tools. Generator is powered by Chrysler industrial engine. Idling device slows engine down when arc is broken and brings it up to operating speed when arc is started. Mercury-type time delay switch allows time to change electrodes without slowing down engine. *The Hobart Brothers Co., Troy, O.*

**Helical Gear Grinder:** Designed primarily for high-precision form grinding of helical gears; may also be used for spur gears and splines. To maintain true helix angle, or lead, an accurately ground master lead bar operates through a pressure lubricated self-tightening antibacklash saddle nut, with the work drive headstock coupled through the index plate to one end of the bar. Lead bar reciprocation causes work to oscillate. Column of grinder mounted on machine base is located by two circular slots to position the wheel for desired helix angle of the gear. Automatic mechanical indexing is actuated by motion of lead bar. Housing for grinding wheel spindle is positioned vertically on the column by a handwheel-operated elevating screw. Equipped with precision wheel dressers for any tooth forms, including involute, root diameter, full root radius, angle and root fillet dressers. *National Broach & Machine Co., Detroit, Mich.*

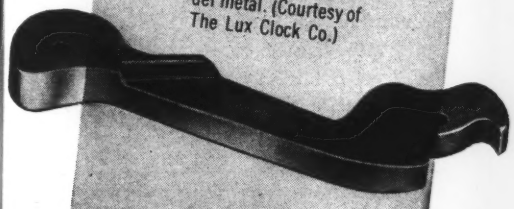
**Tube Bender:** Bends ½-in. and ⅝-in. OD copper, aluminum, brass and other soft thin-wall metal tubing. Dual-size shoe and mandrel permits bending both sizes without changing any parts. Two-piece construction comes apart quickly to slip over tube at point where bend is desired. Up to 180 deg bends can be made; bender is calibrated to show degree of bend. Made of steel and aluminum. Overall length 21 in.; weight, 3 lb. *The Imperial Brass Mfg. Co., Chicago, Ill.*

**Shaping Machine:** High-speed floor model with swinging table. Manufactured by Newey Engineering Co., Nottingham, England. Has 18-in. stroke, 35-in. ram and four speeds varying from 22 to 115 strokes per minute. Specifications:

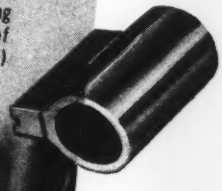
# How to 80% on Many Metal Parts



A spur and mitre gear for a business machine for which powder metal processing eliminates 15 machining and assembly operations. (Courtesy of Powdered Metal Products Corp. of America)



11 radii, 2 through holes, different levels, assembly problems... make this alarm actuating mechanism a forbidding production problem except in powder metal. (Courtesy of The Lux Clock Co.)



Lock cylinders are now widely made of brass powder in a fraction of the time formerly taken to machine them, and without metal cutting loss. (Courtesy of Kwikset Locks, Inc.)

Make them of powder metal!

A clock part of the peculiar shape shown defies successful and economical production by machining, casting or stamping. Powder metal does it for less than 50% of previous cost, and improves quality.

A business-machine gear is made of powder metal at a saving of 80% over previous costs by any other method.

Lock cylinders, ill-adapted to machining, are made at the rate of dozens per minute on powder metal presses.

Powder metal processing holds labor to a negligible per-unit cost. Scrap loss and cutting loss are eliminated. And the user is independent of market conditions affecting the cost and availability of sheet, bar and ingot.

Powder metals and alloys of many kinds are readily available at low and stable costs. Parts can be made in diameters up to 10 inches . . . tolerances as low as .001 inch . . . tensiles as high as 120,000 psi . . . production to 5000 pieces or more per press per hour.

Stokes made the first powder metal press over 30 years ago and has been working in powder metal design ever since. Stokes engineers are available for consultation on the application of powder metal to the production problems of manufacturers.

"Powder Metallurgy Today" is an informative booklet for manufacturers who wish to cut costs on metal parts. Copy available on request.

**STOKES**

**STOKES MAKES**

**Plastics Molding Presses,**
**Industrial Tabletting**
**and Powder Metal Presses,**
**Pharmaceutical Equipment,**
**Vacuum Processing Equipment,**
**High Vacuum Pumps and Gages,**
**Special Machinery**

**F. J. STOKES MACHINE COMPANY, 5556 TABOR ROAD, PHILADELPHIA 20, PA.**